328683 ORIGINAL (Red) GROUND-WATER CONTAMINATION AT ALLIED CHEMICAL CORPORATION (NORTH) PLANT SITE MOUNDSVILLE, WEST VIRGINIA

GROUND-WATER CONTAMINATION AT

ALLIED CHEMICAL CORPORATION

(NORTH) PLANT SITE

MOUNDSVILLE, WEST VIRGINIA

May 1978

Geraghty & Miller, inc.

Consulting Ground-Water Geologists and Hydrologists
Water Research Building
Port Washington, New York 11050

Geraghty & Miller, Inc.

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INTRODUCTION

At a meeting on November 14, 1977, in Morristown, New Jersey, Allied Chemical Corporation requested that Geraghty & Miller, inc. perform a hydrogeologic study at the Specialty Chemicals Division (North) Plant near Moundsville, West Virginia. Ground water pumped from Ranney Collector-MDN (called Ranney Collector E in this report) is the North Plant's only water supply for plant operations and it has been contaminated for some time. The contaminants are interfering with the manufacture of high quality products.

There were several purposes of the study. The first objective was to install a permanent observation well network similar to the one installed by Geraghty & Miller, Inc. at the South Plant which would comply with ground-water monitoring requirements of the Resource Conservation and Recovery Act of 1976 (RCRA), a law enacted to regulate hazardous waste disposal facilities. After the observation well network was in place, it was to be used to obtain ground-water quality and water-level data for the purposes of determining the severity of contamination beneath the waste disposal area, defining the flow paths of particular contaminants in

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the ground-water system, and determining whether or not contaminated ground water is migrating offsite either to the Ohio River or to neighboring wells. The composition of dissolved organic contaminants in water being drawn from Ranney Collector E was to be ascertained. An attempt would also be made to determine whether the discrete organic phase accumulating in the caisson of the Ranney well is also present in the adjacent aquifer and whether a geophysical investigation to locate bedrock depressions which may be harboring pools of organics would be worthwhile.

Geraghty & Miller, Inc. was also requested to recommend remedial action to alleviate the ground-water contamination problem with the objectives of eventually improving the quality of ground water used in the plants and restricting contamination to the plant site if any offsite migration is occurring. In addition to installing the permanent monitoring well network to satisfy a requirement of RCRA, remedial or corrective action necessary to bring the waste disposal facilities (ponds and dumps) into compilance with the law was also to be recommended.

The study began with a review of the available literature and plant data. Following this a field investigation was performed involving the installation of observation wells in which potentiometric levels of the ground water were measured and from which ground-water samples were collected for analysis. The following describes the findings and presents conclusions and recommendations.

SUMMARY OF CONCLUSIONS

- 1. With the exception of the area immediately to the east of the production facilities, ground water at the Moundsville plant site has become contaminated with both organic and inorganic compounds.
- 2. The primary source of pollutants which are contaminating Ranney Collector E appears to be the chemical trash dump area to the west of Ranney well.
- 3. Secondary sources of contamination of Ranney Collector E are apparently the North Plant's waste ponds, in particular the NAD pond and the TDI residue pile, although the quantity of contaminants contributed by these facilities appears to be somewhat less than that contributed by the chemical trash dump area.
- 4. The chemical trash dump is apparently the source for most of the organic contaminants arriving at Ranney Collector E, while most of the inorganic pollutants appear to originate in the HAD pond and TDI residue pile area.
- 5. The organic compounds that are contaminating Ranney Collectors B, C, and D apparently originate in the area of the North Plant that was formerly used to manufacture and store aniline, although other smaller sources of these contaminants may exist.
- 6. A flow net constructed from ground-water elevation measurements shows that contaminated ground water is not migrating

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off the plant property. Neighboring wells and the Ohio River do not appear to be in danger of becoming polluted.

- 7. Contaminated ground water will remain confined to plant property if a suitable minimum pumping rate is maintained in the Ranney wells in order to keep the water levels in the aquifer below that in the Ohio River.
- 8. There is no evidence to substantiate the presence of a separate organic phase at the base of the aguifer. Data gathered by Geraghty & Miller, Inc. during this and other contamination studies suggest that organics in shallow aquifers migrate as "emulsions" rather than discrete phases.
- 9. The high chloride concentrations that were found in the aquifer east of Ranney Wells C and D suggest that the salt water from the deep brine wells has contaminated the shallow ground-water system. The wells or distribution system may be leaking, or brine may have been spilled on the ground during redevelopment work on the wells.

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SUMMARY OF RECOMMENDATIONS

Compliance with RCRA

- 1. In order to limit the amount of contaminants that is permitted to enter the ground water, the active unlined waste facilities should be abandoned as soon as suitable "secure" replacements can be constructed. Abandoned facilities should be graded to a gentle slope or slightly convex, then covered with a low permeability cover to prevent infiltration and leaching by precipitation.
- 2. A ground-water quality monitoring program should also be established to detect changes in the chemical quality of ground water, and to confirm that contaminants are being prevented from migrating beyond the plant boundaries.
- 3. In order to restrict contaminated ground water to the plant property, the Ranney collectors should be pumped at a rate sufficient to keep the water table below the water level in the Ohio River and below the bottoms of the waste ponds at all times. Ranney well water could then be treated for use in the plant. Considerations should be given to sealing laterals that extend toward the river.
- 4. In order to verify that the water table remains below the Ohio River level, a ground-water level monitoring program is recommended. Water levels should be measured at least monthly in all of the observation wells and continuously in two new 8-inch deameter wells (one each in the North and South plants) fitted with

automatic water-level recorders.

Consideration should be given to protecting waste disposal facilities from flooding.

Improvement of Ground-Water Quality

- i. Even if the regulations promulgated under RCRA are less stringent than their present draft form, remedial action recommended in order to comply with the draft regulations will eventually result in an improvement of ground-water quality.
- 2. The chemical trash dump and the old aniline storage area in the North Plant and the CMP-sulfuric acid dump in the South Plant should not be excavated to eliminate these sources of ground-water contamination. Excavation and disposal of the wastes from these areas will be very difficult technically, will probably result in additional contamination of the environment, may be dangerous, and will be extremely expensive (probably prohibitive).
- 3. The use of scavenger wells to capture leachate from the waste ponds should be investigated. Scavenger wells will further reduce the quantity of contaminants reaching the ground-water system, provided a practical and enonomical way to treat the effluent from the wells can be found.
- 4. No geophysical investigation to locate bedrock depressions that may be harboring organic contaminants should be undertaken. Such an investigation will yield little useful information for a large expenditure.

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FIELD INVESTIGATION

tions at the North Plant between January 30, 1978 and February 21, 1978. The locations of these wells and Wells 1 through 18, which were installed during previous investigations, are shown on Plates 1 through 11 (back pocket of this report). Most wells are in clusters of three, although there are several clusters of two. Five single wells were also drilled. Most of the wells completed recently were drilled in clusters in order to obtain a vertical profile in addition to an areal profile of ground-water contamination.

At each cluster, a deep well (marked "A") was drilled to bedrock using the hollow stem auger method. Geologic samples were collected every five feet (where possible) with a split core barrel. Water levels were measured in order to determine the saturated thickness of the aquifer, and then 2-inch diameter black steel casing attached at a 3-foot galvanized steel well point was installed in the hole. Each well was completed by packing sand around the well point, setting a bentonite seal above the screen to prevent surface contamination from entering the well, and then backfilling the borehole with drill cuttings. The saturated thickness of the aquifer as measured in the deep ("A") well was used to determine the number of additional wells to be drilled at each cluster. At clusters of three wells, the "B" well was completed approximately mid way between the water table and bedrock and the "C" well was completed about five feet below the water table, although the exact depths vary. Figure 1 shows the construction of



cluster number 26, which is typical, and Table I shows the depth and construction details of each well in addition to depth-to-water measurements. Geologic logs of selected wells have been included in Appendix A and all the geologic samples collected have been stored in the warehouse at the North Plant for future reference.

After completion of a cluster, each well was bailed dry, or one well volume of water was removed if ground water re-entered the well more quickly than it could be bailed out. Samples were collected the following day after the water level has had an opportunity to recover. This was done to insure that the sample obtained represented aguifer water. Samples were collected from the observation wells recently installed and from Observation Wells 1, 16, 17, 18, RT3 (Ranney Test Well 3), Well PT1 (constructed by Dr. Wayne Pettyjohn during his investigation in 1973), the Ohio River (samples R1 and R2), and the NAD pond. Samples from Ranney Collector E and Observation Well 19 were sent to Penn Environmental Consultants in Pittsburgh for mass spectrometry analysis in order to identify organic compounds. Observation Well 19 was considered to have been completed in an area where organic contamination from the plant could not have affected ground-water quality significantly. Tables 2, 3, 4, and 5 contain the analytical results of the water sampling program. Analyses for inorganic constituents and metals were performed by Penn Environmental Consultants in Pittsburgh while Allied's lab at the North Plant analyzed water samples for organic compounds.



Table 1. Summary of Construction Details for Observation Wells.

Well No.	Depth (feet be- low land surface)	Well Point Setting (feet be- low land surface)	Elevation of Top of Casing (feet above mean sea level)	Elevation of Land Surface (feet above mean sea level)	Depth to Water (feet be- low top of casing) 4/5/78	Elevation of Static Water Level (feet above mean sea level)
1	38.2	34.7-38.2	706.93	704.9	34.22	672.7
1	75.0	71.5-75.0	700.29	698.2	60.93	639.4
2	94.6	91.1-94.6	689.96	686.5	-	-
2 3 4 5 6 7 8	85.4	81.9-85.4	669.58	667.3	47.20	622.4
<u> </u>	94.6	91.1-94.6	671.56	668.4	49.99	621.6
6	69.9	66.4-69.9	642.66	641.4	21.04	621.6
7	69.7	66.2-69.7	643.33	641.5	20.47	622.9
Ŕ	65.8	62.3-65.8	644.13	642.0	20.90	623.2
ğ	64.0	60.5-64.0	642.17	640.2	18.55	623.6
10	84.7	81.2-84.7	668.43	665.8	44.73	623.7
••		•••				
11	96.2	92.7-96.2	680.30	678.4	56.52	623.8
12	94.3	90.8-94.3	693.81	690.6	69.64	624.2
13	89.1	85.6-89.1	705.16	701.5	58.08	647.1
14	85.5	82.0-85.5	686.46	684.1	62.63	623.8
15	32.0	29.0-32.0	644.17	642.8	20.37	623.8
16	35.8	32.8-35.8	645.98	643.0	23.01	623.0
17	54.3	51.3-54.3	651.09	649.8	29.55	621.5
18	51.7	48.7-51.7	653.50	650.0	31.15	622.4
19	39.5	36.5-39.5	696.31	696.0	31.30	665.0
20A	75.3	72.3-75.3	659.27	657.6	36.87	622.4
20B	62.1	59.1-62.1	657.86	657.3	35.45	622.4
20C	51.2	49.2-51.2	657.51	657.2	34.85	622.7
21A	67.2	64.2-67.2	672.26	672.0	42.36	629.9
21B	52.1	49.1-52.1	671.47	671.3	41.74	629.7
22A	45.3	42.3-45.3	646.65	644.3	25.94	620.7
22B	27.5	24.5-27.5	644.17	643.9	20.70	623.5
23A	40.2	37.2-40.2	640.79	638.3	23.68	617.1
2 3B	31.9	28.9-31.9	638.82	638.2	21.60	617.2
24A	94.4	91.4-94.4	639.04	636.3	22.88	616.2
248	61.1	58.1-61.1	636.92	636.0	19.82	617.1
-1-			4.4 41	40-0		
24C	36.6	33.6-36.6	636.64	635.8	19.52	617.1
25A	74.0	71.0-74.0	635.38	633.0	17.75	617.6
25B	53.3	50.3-53.3	634.83	632.9	17.15	617.7
25C	32.2	29.2-32.2	634.33	632.8	16.43	617.9
26A	84.4	81.4-84.4	638.65	636.9	37.96	600.7
26B	58.8	55.8-58.8	637.88	636.9	19.83	618.1
26C	37.3	34.3-37.3	638.09	636.7	18.52	619.6
27A	74.1	71.1-74.1	642.79	640.3	27.56	615.2
27B	53.6	50.6-53.6	641.41	640.0	25.84	615.6
27C	-	-	642.47	640.3	26.34	616.1

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Table 1. (Continued)

Well No.	Depth (feet be- low land surface)	Well Point Setting (feet be- low land surface)	Elevation of Top of Casing (feet above mean sea level)	Elevation of Land Surface (feet above mean sea level)	Depth to Water (feet be- low top of casing) 4/5/78	Elevation of Static Water Level (feet above mean sea level)
Ranney Collector	_	-	658.30	-	37.29	621.0
Ranney Collector	-	-	658.30*	-	36.31	622.0
Ranney Collector	-	-	658.30*	-	36.15	622.2
Ranney Collector E PT-1	-	- -	658.50	-	21.03	:

^{*}Estimated

eli o.	Date of Sample	ρН	Alkalinity as CaCO3 (mg/l)	Sulfate (mg/l)	Specific Conductance (umhos/cm)	Hardness EDTA (mg/l)	Calcium (mg/l)	Chloride (mg/l)	Residue (mg/l)	a) (
	-		201	275	1200	510	160	150	810	
onney E	2- 2-78	6.8	204	2/5 225	1230	127	182	145		
anney E	4-6-78	6.9		225	320	144		23		
nuey L	6- 6-77	8.2		4	310	26	40	24		
1	4- 6-78	7.1		4			•	197		
-	8-23-77	6.4		288	1250					
15	0 20 7.	•			2000			803		
1.	8-23-77	6.3		376	3000	216	320	565		
16	4- 6-78	6.7		300	2700	210	4 -0	141		
16	8-23-77	6.6		70	800	49	62	229		
17	8-23-77 4- 6-78	6.8		20	970	47	V 2	211		
17	4- 6-76 8-24 - 77	10.1		45	900					
18	8-24-//	10.1					95	196		
	70	6.7		3	790	64	64.8	16	310	
18	4- 6-78		9960	20	650	5240	702	1250	4300	
19	2- 2-78	7.8	2200	880	5200	3120		930	5200	
20 A	2-1-78	6.9	910	1590	5300	3260	905	380	3580	
20 B	2- 2 - 78	6.6	4130	2300	4200	7200	821	300		
20 C	2- 3-78	6.3	4130	2000				275	884	
			170	110	1330	1560	205	950	2060	
21A	2 - 7 - 78	6.8	170	60	3220	1880	429		1530	
21 B	2- 7 <i>-</i> 78	6.5	360	275	2330	1180	286	340	2260	
22 A	2- 7 - 78	7.1	500	485	3000	1540	369	350	2392	
22B	2- 7 - 78	7.2	468		3770	800	153	640	2372	
23 A	2- 8-78	6.6	490	665	J. , U			446	1710	
247				525	3220	1700	357	660	6050	
23 B	2- 8-78	6.0	240	525	11100	1120	185	3520	332	
	2- 9-78	7.4	410	27	540	960	74.3	40		
24 A	2- 9-78	7.6	400	125		1460	262	360	1548 312	
24 B	2- 7-78 2- 9-78	6.5	415	450	2330 440	140	38	51	312	
24 C 25 A	2-13-78	6.8	84	115	41 0					

Table 2. Concentrations of Dissolved Inorganic Constituents in Ground Water.



Well No.	Date of Sample	ρH	Alkalinity as CoCO3 (mg/l)	Sulfate (mg/l)	Specific Conductance (umhos/cm)	Hardness EDTA (mg/l)	Calcium (mg/l)	Chloride (mg/l)	Residue (mg/l) ^{a)}
1401	Jumpie		("'9/ '/	(***9/ 1)	(dilitios/ Citi)	\'''9/ '/	(mg/ i/	(mg/ i)	(mg/1) '
25B	2-13-78	7.3	146	125	490	280	78	31	377
25C	2-13-78	6.3	72	120	430	200	43	41	303
26A	2-13-78	7.8	1000	135	1700	450	120	400	1220
26B	2-13-78	7.2	148	125	510	260	63	47	359
26C	2-13-78	7.5	10080	525	2900	1500	280	540	4053
26B	4- 7-78	7.1		98	570	252	63	51	
26C	4- 7 - 78	7.8		480	2900	142		4810	
27A	2 - 15 - 78	7.4	88	105	390	180	48	18	282
27B	2-15-78	7.5	94	9 5	370	180	52	18	282
28A	2-13-78	7.6	98	105	390	170	53	30	296
288	2-13-78	7.4	100	95	380	180	56	20	286
28C	2-13-78	6.6	74	90	300	160	45	25	296
29A	2-15-78	7.0	86	85	390	162	43	18	279
29B	2-15-78	6.2	168	150	780	420	31	87	574
29C	2-15-78	6.4	62	75	320	144	89	22	223
30A	2-16-78	6.4	616	380	3300	1370	480	735	2448
30B	2-16-78	6.7	770	115	1300	810	220	200	880
30C	2-16-78	5.9	126	495	2600	900	290	590	1780
31A	2-16-78	7.1	80	1 <i>7</i> 0	4300	1000	370	1400	2723
31B	2-16-78	7.4	206	140	1800	428	165	380	1036
31C	2-16 <i>-</i> 78	6.4	224	370	12000	2430	670	4500	7990
32A	2-21-78	6.5	600	263	6050	1980	780	1576	4170
32B	2 - 21 <i>-</i> 78	6.4	962	722	3580	2090	650	549	3060
32C	2-21-78	6.6	1824	224	1950	1640	360	255	1190
33A	2-21-78	6.3	550	576	13700	3840	1420	5008	10000

Table 2. (Continued)

Well No.	Date of Sample	рН	Alkalinity as CoCO3 (mg/l)	Sulfate (mg/l)	Specific Conductance (umhos/cm)	Hardness EDTA (mg/l)	Calcium (mg/l)	Chloride (mg/l)	Residue a)
							•		
33B	2-21-78	6.7	646	226	1720	1040	314	265	1330 584 9760 1470
33C	2-21-78	6.5	124	117	880	390	102	131	584
34A	2-22-78	6.7	444	466	14250	1960	800	5110	9760
34B	2-22-78	6.9	538	232	2080	960	300	277	1470
34C .	2-22-78	6.6	164	201	930	430	100	92	606
37A	2-17 <i>-</i> 78	6.7	596	495	6100	2480	830	1700	4065
37B	2-17-78	7.3	350	270	2600	1060	360	560	1730
37C	2-17-78	7.1	270	200	1600	720	220	300	1020
38A	2-22-78	7.0	526	933	16630	920	290	6528	12300
38B	2-22-78	6.9	414	340	10690	780	240	3478	6620
38C	2 <i>-</i> 22 <i>-</i> 78	6.5	258	946	21800	1440	340	8823	15500
39	2-21-78	6.6	110	72	340	330	45	41	278
40	2-20-78	7.0	278	90	750	390	100	37	504
Pr 1 b)	4- 7-78	7.2		2	210	10	14	26	
R1 c)	4- 7-78	7.3		62	260	20	30	22	
R 2 d)	4- 7-78	7.3		55	270	19	28	20	
RT 3 e)	4- 6-78	7.4		2	1230	78	103	358	
NAD Pond	4- 6-78	5.4		225	9500	230	350	4441	

a) Filtered, on ignition at 180°C

Table 2. (Continued)

b) Four-inch diameter test well drilled during a previous hydrogeologic investigation performed by Dr. Wayne Pettyjohn

c) River sample near Ranney Collector E (see plates)

d) River sample near Observation Well Cluster 26 (see plates)

e) Ranney Test Well No. 3 (see plates)

Well No.	Date of Sample	Total Organic Carbon (ppm)	Toluene (ppm)	Monochloro- benzene (ppm)	Dichloro- benzene (ppm)	Nitro- benzene (ppm)	Aniline (ppm)	Mono- nitro- toluene (ppm)	Dinitro- toluene (ppm)	Toluidines (ppm)	o-Toluene- diomines (ppm)	m~foluene~ diamines (ppm)	Pheno (ppm)
Ranney E	2-1-78 4-6-78	14	<0.1	0.5	1.9	3.4	1	0.3	0.5	<1	<1	< :	<1
Ranney E	4- 0-/6		<0.1	0.6	4.0	5.6	<1	< 0.1	0.4	< 1	<1	<1	<1
1	4- 6-78		<0.1	< 0.1	< 0,1	<0.1	<1	-0.1	-0.		- •		
15	8-23-77	55	•••	-0.1	-0,1	~0,1	~1	< 0.1	< 0.1	<1	<1	<1	< 1
16	8-23-77	95	< 0.1										
16	4- 6-78		<0.1	1.9	4.0	3.1	4	< 0.1	0.2	<1	<1	<1	<1
17	8-23 - 77	178				-	-	 -			- •	~1	- •
17	4- 6-78		< 0.1	< 0.1	<0.1	< 0.1	<1	< 0.1	< 0.1	<1	<1	<1	<1
18	8-24-77	128							-	-		•	
18	4- 6-78		<0.1	< 0.1	<0.1	< 0.1	ı	< 0.1	< 0.1	<}	<1	<1	< 1
19	2- 2-78	14	< 0.1	< 0.1	<0.1	< 0. l	<1	< 0.1	< 0.1	< i	<1	<1	< 1
20A	2- 2-78		< 0.1	1.0	1.6	< 0.1	6	< 0.1	< 0.1	<1	<1	<1	< 1
208	2- 2-78		< 0.1	0.2	< 0.1	< 0.1	37	< 0.1	< 0.1	<1	<1	< i	< 1
20C	2- 3-78		< 0.1	< 0.1	< 0.1	5.4	3	< 0.1	< 0.1	<1	<1	<i< td=""><td>< 1</td></i<>	< 1
21A	2- 7-78		< 0.1	< 0.1	< 0.1	< 0.1	16	< 0.1	< 0.1	<1	<1	<1	< 1
21B	2-7 -78		< 0.1	< 0.1	< 0.1	2.2	351	2.5	33.4	< i	<1	<1	< 1
22A	2- 7-78		< 0.1	1.3	4.0	< 0.1	1	< 0.1	< 0.1	< i	<1	<1	< 1
22B	2- 7-78		< 0.1	1.5	0.1	< 0.1	< }	< 0.1	0.1	<1	<1	< i	< 1
23A	2- 8-78		< 0.1	< 0.1	< 0.1	< 0.1	2	< 0.1	< 0.1	< i	<1	<1	< 1
23ь	2- 8-78		< 0.1	< 0.1	1.8	< 0.1	4	< 0.1	< 0.1	<1	<1	<1	< 1
24A	2- 9 - 78		< 0.1	7.6	28.7	113.1	400	5.2	5.2	<1	<1	<1	< 1
248	2- 9 - 78		< 0.1	0.3	4.7	< 0.1	<1	0.5	0.1	<1	<1	<1	< 1
24C	2- 9-78		< 0.1	< 0.1	0.1	< 0.1	31	< 0.1	< 0.1	<1	<1	<1	< j
25A	2-13-78		< 0.1	1,2	5.6	< 0.1	81	< 0.1	< 0.1	<1	<1	<1	< i

Table 3. Concentrations of Dissolved Organic Compounds in Ground Water.

Well No.	Date of Sample	Total Organic Carbon (ppm)	Toluene (ppm)	Monochloro- benzene (ppm)	Dichloro- benzene (ppm)	Nitro- benzene (ppm)	Aniline (ppm)	Mono- nitro- toluene (ppm)	Dinitro- toluene (ppm)	Toluidines (ppm)	o-Toluene - diamines (ppm)	m-foluene- diomines (ppm)	Phenol, (ppm)
258	2-13-78		< 0.1	< 0.1	0.1	<0.1	<1	< 0.1	< 0.1	< 1	<1	<1	<1
25C	2-13-78		< 0.1	< 0.1	< 0.1	<0.1	<1	< 0.1	< 0.1	< 1	< 1	<1	<1
26A	2 - 13-78		< 0.1	< 0.1	< 0.1	136	540	< 0.1	< 0.1	<1	973	339	98
26 6	2-13-78		< 0.1	< 0.1	10	< 0.1	8	< 0.1	< 0.1	<1	*/3 <1	<1	<1
26C	2-13-78		< 0.1	< 0.1	12	742	3213	< 0.1	< 0.1	<1	15067	5055	416
2ó8	4- 7- 78		< 0.1	< 0.1	< 0.1	11	10	< 0.1	< 0.1	<1	<1	<1	<1
26 C	4- 7-78		< 0.1	< 0.1	< 0.1	604	3205	< 0.1	< 0.1	5585	18220	709	229
27A	2-15-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	<0.1	< 0.1	< 1	<1	<1	<1
27B	2-15-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	<0.1	<0.1	<1	<1	<1	<1
28A	2-13-78		< 0.1	4.8	39.9	336.2	27	12.5	25.4	<1	<1	<1	<1
288	2-13-78		< 0.1	< 0.1	1.1	2.5	<1	< 0.1	<0.1	<1	<1	<1	<1
28C	2-13-78		< 0.1	.<0.1	0.3	< 0.1	< i	0.1	0.2	< 1	<1	<1	<i< td=""></i<>
29A	2-15-78		< 0.1	< 0.1	< 0.1	<0.1	<i< td=""><td><0.1</td><td>< 0.1</td><td>< i</td><td><1</td><td><1</td><td>< i</td></i<>	<0.1	< 0.1	< i	<1	<1	< i
29B	2-15-78		< 0.1	< 0.1	< 0.1	<0.1	<1	< 0.1	< 0.1	<1	<1	<1	<i< td=""></i<>
29C	2-15-78		< 0.1	< 0,1	< 0.1	<0.1	<i< td=""><td><0.1</td><td>< 0.1</td><td>< 1</td><td><1</td><td><1</td><td><1</td></i<>	<0.1	< 0.1	< 1	<1	<1	<1
30A	2-16-78		< 0.1	8.3	22.7	6.4	9	<0.1	0.3	<1	<1	< 1	<1
30B	2-16-78		< 0.1	0.6	1.4	0.1	59	<0.1	0.1	<1	<1	<1	< 1
30C	2-16-78		< 0.1	< 0.1	1,4	< 0.1	2	<0.1	< 0.1	<1	< 1	<1	< 1
31A	2-16-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	< 0.1	< 0.1	<1	<1	< 1	< }
31B	2-16 <i>-</i> 78		< 0.1	< 0.1	< 0.1	< 0.1	<1	<0.1	< 0.1	<1	< 1	< }	<1
31C	2-16-78		<0.1	<0.1	< 0.1	<0.1	<1	<0.1	< 0.1	<1	<1	<1	<1
32A	2-21-78		0.3	2.8	4.1	< 0.1	19	< 0.1	<0.1	<1	<1	<1	<1
32B	2-21-78		0.7	<0.1	< 0.1	< 0.1	2	<0.1	< 0.1	<1	<1	<1	<1
32C	2-21-78		< 0.1	<0.1	< 0.1	< 0.1	<Ī	< 0.1	< 0.1	< Î	<1	< 1	<1
33A	2-21-78		2.1	2.0	7.0	10.5	9	1.3	6.2	<1	<1	< 1	< 1
338	2-21-78		<0.1	0.1	0.5	2,1	5	<0.1	<0.1	<1	<1	<1	<1

Table 3. (Continued)

Well No.	Date of Sample	Total Organic Carbon (ppm)	Toluene (ppm)	Monochloro- benzene (ppm)	Dichloro- benzene (ppm)	Nitro- benzene (ppm)	Antifine (ppm)	Mono- nitro- toluene (ppm)	Dinitro- toluene (ppm)	Toluidines (ppm)	o-Toluene – diamines (ppm)	m-foluene- diamines (ppm)	Pheno! (ppm)	Geragh
226	2-21-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	< 0.1	< ⊍. 1	<1	<1	<1		पु %
33¢	7-21-78		<0.1	0.5	2.8	< 0.1	48	< 0.1	< 0.1	< 1	<1	<1	<1	7
34A 34B	2-22-78		<0.1	< 0.1	<0.1	< 0.1	< }	< 0.1	< 0.1	< }	< 1	< 1	< }	E
34C	7-22-78		<0.1	< 0.1	< 0.1	< 0.1	<1	< 0.1	< 0.1	< l	<1	< 1	< 1	Miller
3/A	2-17-78		<0.1	3.6	1.9	7.8	9	< 0.1	< 0.1	< 1	<1	<1	< 1	_
37B	2-17 - 78		<0.1	< 0.1	< 0.1	< 0.1	<1	< 0.1	< 0.1	<1	<1	<1	< 1	nc.
37C	2-17-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	< 0.1	< 0.1	< <u>}</u>	<1	< <u>]</u>	< 1	
38A	2-22-78		< 0.1	<0.1	< 0.1	0.3	<)	< 0.1	< 0.1	</td <td><1</td> <td>< 1</td> <td><1</td> <td></td>	<1	< 1	<1	
38B	2-72-78		< 0.1	< 0.1	0.1	< 0.1	<1	< 0.1	< 0.1	< 1	<1	<1	< 1	
387	2 <i>-</i> 22-78		< 0.1	<0.1	0.4	< 0.1	<1	< 0.1	<0.1	<1	<1	<1	< 1	
39	2-21-78		<0.1	< 0.1	0.2	< 0,1	<1	< 0.1	< 0.1	< <u>1</u>	<1	<1	< 1	
40	2-20-78		< 0.1	< 0.1	3.2	< 0.1	<1	< 0.1	< 0.1	<1	<1	<1	< 1	
PT 1	4-7-78		<0.1	< 0.1	< 0.1	< 0,1	<1	< 0.1	< 0.1	< 1	<1	<1	<1	
Ri	4- 7-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	< 0.1	< 0.1	< !	<1	<1	< 1	
R 2	4- 7-78		< 0.1	< 0.1	< 0.1	< 0.1	<1	0.1	0.4	<1	<1	<1	< 1	
RT 3	4- 6-78		< 0.1	< 0.1	< 3,1	< 0,1	<1	<0.1	0.6	<1	<1	< i	< I	
	d 4- 6-78		<0.1	< 0.1	< 0.1	< 0.1	260	< 0.1	< 0.1	<1	<1	<1	< 1	

Table 3. (Continued)

Well No.	Date of Sample	Cadmium (mg/l)	Chromium (mg/l)	Iron, total (mg/1)	Potassi um (mg/l)	Magnesium (mg/l)	Manganese (mg/l)	Sodium (mg/l)	Nickel (mg/l)	Lead (mg/l)	Mercur (ug/l)
Ranney E	2- 2-78	< 0.01	0.01	3.8	3,2	30	4.0	65	< 0.03	0.05	< 0.5
Ranney E	4- 6-78 6- 6-77	< 0.01	< 0.01	1.45	2.88	27	3.95	67	< 0.03	< 0.03	
1	4- 6-78	< 0.01	< 0.01	0.45	1.97	2.6	1.09 2.16	26	< 0.03	< 0.03	0.4
15	8-23-77		< 0.01		. •	- - -	2010		70.00	70.00	
16	8-23-77		< 0.01							,	
6	4- 6-78	< 0.01	< 0.01	78.1	6.6	38	31.5	210	0.07	0.05	
7	8-23-77		< 0.01								
7	4- 6-78	< 0.01	< 0.01	0.71	5.7	6.2	0.50	87	< 0.03	< 0.03	
8	8-24-77		< 0.01								
8	4- 6-78	< 0.01	< 0.01	28.0	6.2	9.2	6.73	30	0.03	< 0.03	
9	2- 7 - 78	< 0.01	< 0.01	0.02	2.70	26.2	0.47	24.6	< 0.03	0.03	< 0.
:0 A	2- 7 -78	0.01	0,01	108	12.6	96	20.6	421	0.06	0.14	< 0.
20 B	2- 7-78	0.01	0.02	8.30	11.5	240	12.3	173	0.12	0.18	0.
20C	2- 7-78	0.01	0.02	9.30	6.0	213	81	149	0.10	0.13	< 0.
1 A	2- 7 - 78	< 0.01	< 0.01	30.3	4.61	25.3	11.7	23.1	< 0.03	< 0.03	< 0.
?1 B	2- 7 -78	0.01	< 0.01	16.8	6.5	45	53	58.8	0.07	0.05	<0.
22 A	2- 7 - 78	< 0.01	< 0.01	3.48	5.7	40.5	11.3	143	< 0.03	0.04	< 0.
22 B	2- 7 - 78	< 0.01	0.01	17.1	6.6	75	21.2	166	0.08	0.06	< 0.
23 A	2- 8-78	< 0.01	< 0.01	48.0	3.49	22.8	27.1	670	< 0.03	< 0.03	< 0.
23 B	2- 8-78	0.01	< 0.01	39.5	2,13	55	17.0	205	0.10	0.08	<0.
24 A	2- 9-78	0.01	< 0.01	0.50	36.3	41	20.1	1850	0.03	0.03	< 0.
24 B	2- 9 - 78	< 0.01	< 0,01	0.15	2.91	7.9	3.40	32.7	< 0.03	< 0.03	< 0.
24 C	2- <i>9-</i> 78	< 0.01	0.01	30.8	2.47	48	15.0	167	0.07	0.06	<0.
25 A	2-13-78	< 0.01	< 0.01	0.02	6.8	7.1	0.46	40	< 0.03	< 0.03	< 0.

Table 4. Concentrations of Dissolved Metals in Ground Water.

Well No.	Date of Sample	Cadmium (mg/l)	Chromium (mg/l)	iron , total (mg/i)	Potassium (mg/l)	Magnesium (mg/l)	Manganese (mg/l)	Sodium (mg/1)	Nickel (mg/l)	Lead (mg/l)	Mercury (ug/l)
25B	2-13-78	< 0.01	< 0.01	0.13	1,66	8.8	8.1	19	< 0.03	< 0.03	<0.5
25C	2-13-78	< 0,01	< 0.01	13.5	0.94	7.6	8.2	18	< 0.03	< 0.03	<0.5
26A	2-13-78	< 0.01	< 0.01	0.22	8.8	22	16.8	200	< 0.03	< 0.03	< 0.5
26B	2-13-78	< 0.01	< 0.01	0.11	2,68	7.2	5.3	32	< 0.03	< 0.03	<0.5
26C	2-13-78	<0.01	0.02	0.67	15.8	45	16.3	320	0.03	0.06	<0.5
26B	4- 6-78	< 0.01	< 0.01	0.21	8.2	7.2	• 4.21	32	< 0.03	< 0.03	
27A	2-15-78	< 0.01	< 0.01	0.08	2.60	10	0.45	19	< 0.03	< 0.03	< 0.5
27B	2-15-78	< 0.01	< 0.01	0.06	2,14	9.0	0.43	17	< 0.03	< 0.03	< 0.5
28A	2-13-78	< 0.01	< 0.01	0.13	3.31	8.6	1.42	26	< 0.03	< 0.03	< 0.5
288	2-13-78	< 0.01	< 0.01	0.18	2.48	8.2	1.83	19	< 0.03	< 0.03	< 0.
28C	2-13-78	< 0.01	< 0.01	12.2	2.41	6.6	6.4	23	0.04	< 0.03	< 0.5
29A	2-15 <i>-</i> 78	< 0.01	< 0.01	0.05	2.92	8.8	2.45	16	< 0.03	< 0.03	< 0.
29B	2-15-78	< 0.01	< 0.01	0.83	1,49	6.5	2.22	18	< 0.03	< 0.03	< 0.
29C	2 - 15 <i>-</i> 78	< 0.01	< 0.01	60.4	0.91	14	19.4	12	0.03	< 0.03	< 0.5
30A	2-16-78	0.01	< 0.01	8.2	7.0	3 5	19,1	240	0.10	0.06	< 0.
30B	2-16-78	< 0.01	< 0.01	0.27	19.4	14	13.7	46	< 0.03	0.05	< 0.5
30C	2-16-78	< 0.01	< 0.01	4.06	2,75	24	37.7	210	0.15	0.09	< 0.
31A	2-16-78	< 0.01	< 0.01	0.20	8.5	56	0.87	500	0.03	0.04	< 0.
318	2-16-78	< 0.01	< 0.01	0.03	2,11	14	8.6	183	< 0.03	< 0.03	< 0.5
31C	2-16-78	0.01	0.01	20.0	9.0	107	27.7	1680	0.38	< 0.03	< 0.
32A	2-21-78	0,01	< 0.01	0.04	14.9	80	27.5	470	0.09	0.13	< 0.5
32B	2 <i>-</i> 21 <i>-</i> 78	0.01	< 0.01	3.00	7.8	121	19.9	190	0.08	0.14	< 0.5
32C	2 <i>-</i> 21 <i>-</i> 78	< 0.01	< 0.01	1.86	5.4	48	10.4	85	0.04	0.11	< 0.
33A	2-21-78	0.02	0.02	12.9	18,3	148	38. 5	1800	0.18	0.21	< 0.
33B	2-21-78	0.01	< 0.01	0.37	5,1	46	17.4	79	0.06	0.07	< 0.

Table 4. (Continued)

Well No.	Date of Sample	Cadmium (mg/l)	Chromium (mg/1)	Iron, total (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Manganese (mg/l)	Sodium (mg/l)	Nickel (mg/l)	Lead (mg/l)	Mercury (ug/l)	Geraghty
33C	2-21-78	0.01	< 0.01	3.62	2.72	21.1	0.62	35	0.07	0.04	< 0.5	TY 02
34A	2-22-78	0.02	0.01	10.2	15.2	61	19.0	2500	0.14	0.11	< 0.5	
34B	2-22-78	0.01	< 0.01	0.02	3.43	56	12.2	130	0.06	0.07	< 0.5	Ē
34C	2-22-78	< 0.01	< 0.01	< 0.01	2.00	19.2	3.09	27	0.05	< 0.03	< 0.5	Miller,
37A	2-17-78	0.01	0.02	0.09	9.5	83	48.3	350	0.13	0.14	< 0.5	, Inc.
37B	2-17-78	<0.01	< 0.01	0.02	3.88	34	12.8	151	0.04	0.07	< 0.5	32
37C	2-17-78	< 0.01	< 0.01	0.72	4.23	23	10.7	76	< 0.03	0.03	< 0.5	
38A	2-22-78	0,01	0.01	0.03	15.7	26	7.7	4000	0.17	0.10	< 0.5	
388	2-22-78	0.01	0.01	0.02	4.83	24	19.3	2100	0.14	0.05	< 0.5	
38C	2-22-78	0.02	0.02	0.04	8.9	28	19.6	4700	0.27	0.14	< 0.5	
39	2-21-78	< 0.01	< 0.01	< 0.01	3.10	8.2	1.90	18	< 0.03	0.03	< 0.5	
40	2-20-78	< 0.01	< 0.01	2.32	4.83	25	3.85	26	0.03	0.03	< 0.5	
PT 1	4- 6-78	< 0.01	< 0.01	0.36	8.6	3.8	0.18	18	< 0.03	< 0.03		
R I	4- 6-78	< 0.01	< 0.01	0.09	1.78	6.8	0.17	11	< 0.03	< 0.03		
R 2	4- 6-78	< 0.01	<0.01	0.08	1.71	6.7	0.17	11	< 0.03	< 0.03		
RT 3 NAD	4 6-78	<0.01	<0.01	0,04	18.5	14.9	0.28	87	< 0.03	< 0.03		
Pond	4- 6-78	0.01	1.20	6.07	2.55	25.0	8.7	3080	0.04	0.10		

Table 4. (Continued)

Table 5 - Compounds Identified by Gas Chromotography and Mass Spectrometry.

Constituent	Ranney Collector E 2-2-78 (ppm)	Observation Well 19 2-2-78 (ppm)		
Nitrobenzene	3.2	< 0.01		
m-Dichlorobenzene	0.64	< 0.01		
o-Dichlorobenzene	3.0	< 0.01		
Chiorobenzene	0.49	< 0.01		
Mononitrotoluene	< 0.01	< 0.01		
2,6-Dinitrotoluene	0.55	< 0.01		
Dinitrobenzene	0.01	< 0.01		

Water levels in all of the observation wells and most of the Ranney collectors were measured on February 23, 1978, and again on April 5, 1978. The water-level data were used to construct water table maps (Plates 1 and 2), which were in turn used to determine ground-water flow directions.

In an attempt to determine whether a discrete and separate organic phase similar to that which is accumulating in Ranney Collector E exists in the aquifer, Observation Wells 26A and 26C were "swabbed". Each well was bailed until no more water could be removed; then a ball of cotton attached to a measuring tape was lowered into the tip of the well point where slightly soluble organics more dense than water should have accumulated. The saturated cotton was retrieved and any liquid was squeezed into a glass bottle for analysis.

FINDINGS

Ground-Water Contamination: General

Ground-water quality at the Moundsville plant site is summarized in Tables 2 through 5. Analyses of water from all the wells (except 35 and 36, which were dry), from the Ohio River (Samples R1 and R2), and the NAD pond are given. The analytical results from Well PT I have been included but are probably unreliable because it was not possible to remove a sufficient quantity of water from this well to guarantee a representative ground-water sample.

Much of the information from Tables 2 through 5 was used to prepare

Plates 3 through 11 (back pocket of this report). These were drawn by determining the average concentration of a particular constituent from all water

samples obtained from each well or well cluster, plotting these averages,
and then contouring them. Water-quality data obtained during hydrogeological investigation at the North and South Plants in 1977 were included.

Plates 3 through 11 give an overall vertical and areal view of ground-water

contamination because averaged concentrations of contaminants were used on
the maps. In some cases, where the concentration contour interval is a power
of ten, the maps also reflect, in general, maximum contaminant concentrations
at each cluster or well.

Tables 2 through 5 and Plates 3 through 11 show that, with the exception of the area to the east of the North and South Plant production facilities, ground water under the rest of the site has become contaminated with both in-

organic and organic compounds. The magnitude of contamination can be determined by comparing the analyses of water samples taken from observation wells in the plants, and especially in the waste disposal areas, to those from Observation Wells 1 (background water quality) and 19, which represents ground water that has not been significantly affected by contamination from the plants. Contamination is most severe in the waste disposal areas of both plants, and less severe away from these areas.

Interestingly, ground water in the vicinity of Observation Cluster 27 appears to be virtually uncontaminated, yet Table 6 shows that the laterals extending from Ranney Collector E (see Figure 2) in the direction of the wells in the cluster are the most severely contaminated of all the laterals. In addition, the laterals extending in the direction of the waste ponds and chemical trash dump show the lowest concentration of contaminants. There seems to be no explanation for this anomaly, unless the quantity of river water drawn into laterals 6 and 7 significantly dilutes the contaminants entering them. This seems unlikely because the dilution factor necessary would be too large to account for the anomaly. It is also possible, but also unlikely, that a localized source of contamination is present in the immediate vicinity of laterals 2 and 3. The most likely answer is that an error exists in the original construction drawing of the Ranney collector supplied to Allied.

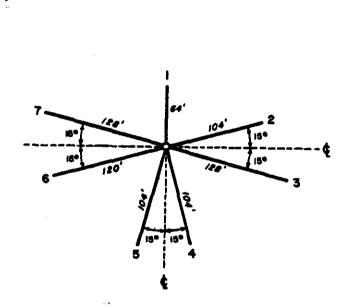
Organic Chemicals in Ground Water

At the North Plant, the primary source of organic pollutants in Ranney Collector E appears to be the chemical trash dump immediately to the west of

	Lateral Number										
Constituent	1	2	3	4	5	6	7				
Hardness (ppm)	550	464	4000	2236	327	327	508				
Conductance (umhos/cm)	1500	1400	4200	2700	270	270	290				
Chloride (ppm)	71	213	23530	9270	142	35	35				
Total Organic Carbon (ppm)	151	60	200	150	60	58	79				
Flow rate (gpm)	251	536	27	153	317	230	180				

This information was supplied by Allied Chemical Corporation. Sampling of Individual laterals was not undertaken by Geraghty & Miller, Inc.

OHIO RIVER



SCALE | " = 100'

NOTE: DIAGRAM SUPPLIED BY ALLIED CHEMICAL CORPORATION.

FIGURE 2

CONSTRUCTION OF RANNEY
COLLECTOR E

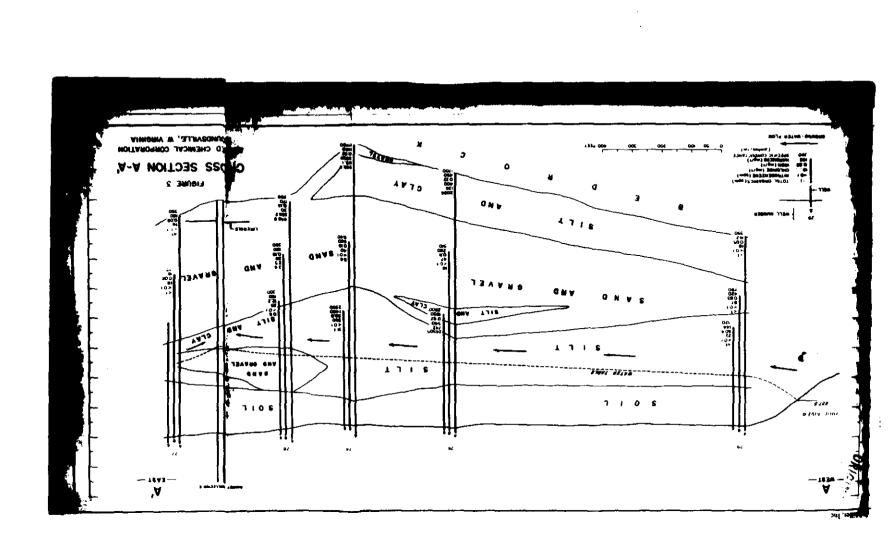
ALLIED CHEMICAL CORPORATION NORTH PLANT MOUNDSVILLE, WEST VIRGINIA

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the collector. The highest concentrations of aniline, chlorobenzenes, and nitrobenzene were found in Clusters 24, 26, and 28, which are on a line extending west from Ranney Collector E (see Table 3 and Plates 3, 4, and 5). The vertical profile through these wells (see Figure 3) also suggests a westerly source for the organic contaminants. Although a moderately high concentration was found in Observation Well 26A, the highest concentration of organics is in Observation Well 26C, the shallow well of that cluster, while the highest concentrations in the other two clusters are in the deep "A" wells. This would be expected if these chemicals were dumped at or near the surface in the vicinity of Cluster 26, then migrated downward and eastward under the pumping influence of the Ranney Collector E. Also, the concentration of total organics (see Plate 6 and Figure 3) decreases from west to east through these clusters. The pollutants would be expected to disperse and become less concentrated as they travelled away from the source.

Toluenediamine was identified in ground-water samples obtained from Cluster 26, but was not found in any other observation wells west of Ranney Collector E or in the Ranney collector itself. Unless this compound was sealed in a drum which was breached during drilling or was otherwise confined in the chemical trash dump, it should have appeared in Clusters 24 and 28 and in the Ranney collector. Gas chromotographic analysis by the North Plant laboratory of water samples from Clusters 24 and 28 and analysis of a water sample from the Ranney well by Penn Environmental Consultants, Inc. did not show the presence of toluenediamine.

The NAD pond and the TDI residue pile undoubtedly contribute some organic



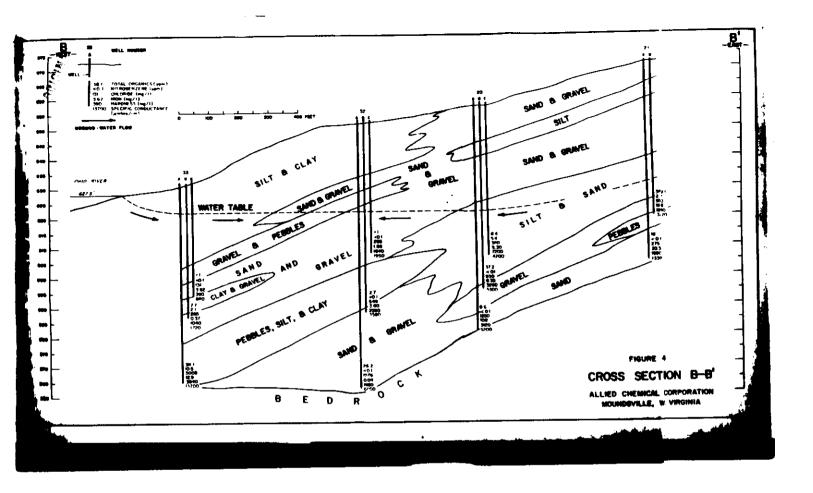
contaminants to the ground water, but apparently in smaller quantities than the chemical trash dump. The high concentration of aniline in the sample collected from the NAD pond and the moderate concentrations of organics in Clusters 23, 25 and 30, which are located between the NAD pond and Ranney Collector E, indicates that the NAD pond and the TDI residue pile are secondary sources of the organics contaminating the Ranney Collector E. It was not possible to determine the relative quantity of organics contributed by Ponds 2 and 3 because the high concentrations of contaminants in the chemical trash dump area have obscured the paths of any organics entering the groundwater system from these sources. The quantity is probably small compared to the amounts from the chemical trash dump, however.

One of the sources for nitrobenzene, dichlorobenzene, and aniline found in water drawn from Ranney Collectors B and C (see Table 7) appears to be in the vicinity of Observation Well Cluster 21, although other smaller sources may also exist. According to plant personnel, this area had formerly been used to manufacture aniline and store organic chemicals in above-ground metal tanks. Water-quality data in Plates 3 through 6 and in Figure 4 demonstrate that a typical ground-water contamination plume emanates from this area. In such a plume, the highest contaminant concentrations would be expected at progressively deeper levels of the aquifer with increasing distance from the source toward the Ohio River. At the same time, the total concentration of contaminants could be expected to decrease areally as the plume is dispersed. Figure 4 shows that the highest organic concentrations are in the shallow well at Cluster 21, in the intermediate depth well at Cluster 20, and in the deep wells at Clusters 32 and 33. Plates 3 through 6 show that the concen-

Table 7 - Concentrations 1) of Organic Chemicals in Ranney Collector Well Water. 2)

		8/18/76	2/9/77	2/18/77	2/22/77	<u>3/9/77</u>	3/16/77
MDN-Well Water (Ranney Collector E) o-DCB p-DCB Nitrobenzene			1.9 0.1 6.4	1.86 0.137 4.58			1.73 0.484 3.50
MDN-Organic Layer o-DCB p-DCB Nitrobenzene	}	68.1% ³ 19.8%					
MDS-"A" WELL (Ranney Collector A) o-DCB p-DCB Nitrobenzene			ND ND ND	< 0.01 (ND) < 0.01 (ND) 0.12	< 0.01 (ND) < 0.01 (ND) 0.03	< 0.01 (ND) < 0.01 (ND) 0.16	
MDS-"B" WELL (Ranney Collector B) o-DCB p-DCB Nitrobenzene				1.02 < 0.01 (ND) 4.09	0.97 < 0.01 (ND) 3.75	1.29 < 0.01 (ND) 4.17	1.17 < 0.01 (ND) 3.39
MDS-"C" Well (Ranney Collector C) o-DCB p-DCB Nitrobenzene				1.08 0.41 3.48	1.09 0.37 5.22	1.33 0.39 8.63	1.52 0.477 11.03
MDS-"D" Well (Ranney Collector D) o-DCB p-DCB Nitrobenzene			0.32 0.03 2.4	1.33 < 0.01 (ND) 1.37	1.17 < 0.01 (ND) 0.72	0.59 0.26 0.68	<0.01 (ND) <0.01 (ND) <0.01 (ND)
Washington Lands Tap Water o-DCB p-DCB Nitrobenzene				< 0.01 (ND) < 0.01 (ND) < 0.01 (ND)		< 0.01 (ND) < 0.01 (ND) < 0.01 (ND)	<0.01 (ND) <0.01 (ND) <0.01 (ND)

¹⁾ Concentrations are in parts per million.
2) This information was supplied by Allied Chemical Corporation.
3) Composition of the organic layer, accumulating in Ranney Collector E.



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tration decreases away from the source as the contaminants are drawn westward by the pumping Ranney collectors.

No evidence could be found anywhere in the aquifer to substantiate the presence of a separate organic phase similar to that accumulating in Ranney Collector E. All of the water samples, including samples obtained during the attempts at swabbing Observation Wells 26A and 26C, were homogeneous at the time of collection and remained so after they had been stored in the laboratory for several weeks. In addition, Table 8 shows that the maximum concentrations of organic substances appear to be well below their solubilities in water. Ground water in contact and in chemical equilibrium with a discrete organic phase would be expected to contain saturation concentrations of the organic compounds. This was not found to be the case.

Although there is no proof that organics are not accumulating at the base of the aquifer, Geraghty & Miller, Inc.'s experience in other ground-water contamination cases involving organic chemicals tends to corroborate the fact that these compounds do not travel as discrete phases in the ground-water system. In one case, benzene concentrations two or three times the theoretical solubility limit were detected, yet a benzene phase never separated even after several weeks of storage in the laboratory at ambient temperature and pressure. In another case, a mixture of organics was found in leachate emanating from waste disposal ponds. The samples appeared homogeneous at the time of collection and remained so for two or three days; then a separate organic phase began to accumulate.

Under the conditions which exist at the chemical trash dump, precipita-

Table 8. Solubilities of Organic Compounds Identified in Ground Water.

Contaminant	Specific Gravity	Compound Temper- ature (OC) 1)	Water Temper- ature (^O C)	Solubility (ppm)	Temper- ature (°C) 2)	Source of Data	Highest Concen- tration (ppm)	Highest Concentration Found in Well
Toluene	0.867	20	4	470	16	Verschueren c)	0.7	32B
Nitrotoluene	1.20 (avg.) ^{a)}	-	~	530 (avg.) ^{a)}	30	Verschueren ^{c)}	12.5	28A i
Dinitrotoluene	1.521 (2,4) b)	- ,	-	270 (2,4) b)	22	Verschueren c)	33.4	218
Monochlorobenzene	1.107	20	4	490	-	Lange d)	8.3	30A
Dichlorobenzene	1.35 (avg.) ^{a)}	20	4	116 (avg.) ^a	25	Verschueren c)	39.9	28A
Ni trobenzene	1.20	25	4	1,900	20	Verschueren c)	742	26C
Aniline	1.022	20	20	34,000	-	Verschueren c)	3,213	26C
Toluidines	0.99-1.046	-	•	11,200 (avg.) a)	25	Verschueren c)	< 1	-
o-Toluenediamine	Solid	-	-	> 10,000 (est.) e)	_	Verschueren c)	18,220	26C
m-Toluenediamine	Solid	-	-	> 10,000 (est) e)	_	Verschueren c)	5,055	26C
Phenol	1.07	•	-	82,000	15	Verschueren c)	416	26C

a) Average specific gravity or solubility of the possible isomers.

b) 2,4 - Dinitrotoluene

c) Verschueren, K., 1977, Handbook of Environmental Data on Organic Chemicals.

d) Lange's Handbook of Chemistry, 1956.

e) Toluenediamine is probably more soluble due to its chemical properties than phenylenediamine, which is soluble to about 196,250 ppm (avg).

¹⁾ Specific gravity of compound measured at this temperature with respect to water at temperature given in Column 4.

Solubility at this temperature.

tion is dissolving some chemicals as it percolates through the residuals.

Some liquid chemical wastes may also be moving downward as an organic phase.

No evidence of an organic phase in the aquifer has been found, leading us to question its existence beyond the immediate deposition zone of liquids.

There is indirect evidence that organic substances can travel as a type of emulsion, which may result from flow through the small pore spaces between sediment grains in the aquifer.

The solubility limits calculated for organic compounds under atmospheric conditions may not apply in the ground-water system. In the aquifer, organic chemicals are subjected to larger hydrostatic pressures (from the weight of overlying water and sediment) which tend to increase solubility, especially of volatile compounds. Release of ground water to atmospheric pressure in the Ranney Collector E may also contribute to the separation of the organics from the aqueous phase.

Inorganic Chemicals in Ground Water

Unlike the findings obtained for organic compounds, there is a less distinct pattern of contamination by inorganic chemicals. The highest concentration of organics appeared in localized areas of the plant, particularly in the waste disposal areas, but this is not true of the inorganics which appear to be much more widespread. Plates 7 through 11 show that the hardness and specific conductance, and iron and manganese concentrations are high over wide areas of the plant site, which indicates that the sources of inorganic contaminants are numerous.

In the North Plant, the primary source of inorganic contaminants, particularly iron and manganese, that are found in Ranney Collector E appears to be the NAD pond/TD! residue pile area, or another source some distance south of this area. The chemical trash dump is almost certainly a secondary source. The lime waste pond may be an important source of hardness but this was not readily apparent from the data obtained; partly because it was impossible to drill observation wells in the pond's immediate vicinity and its contribution of contaminants is probably masked by the inorganics entering the ground warer from the other ponds and the chemical trash dump.

The high concentrations of hardness, specific conductance, and chloride in the area between the North and South Plants to the east of Ranney Collectors C and D suggest that salt water from the deep brine wells has contaminated the shallow ground-water system. The wells or distribution system may be leaking, but most probably large quantities of brine were spilled on the ground during the drilling of the wells or during maintenance operations.

ffects of Ground-Water Pumpage on Contaminant Flow Paths

Plates 1 and 2 show that the water-table elevation in the aquifer is well below the water level in the Ohio River. This condition is caused mainly by the continuous pumping of the Ranney collectors and, while it persists, contaminants which enter the ground-water system anywhere on the plant site should not migrate off the property. The Ohio River and neighboring wells at the Moundsville Country Club and at Washington Lands do not appear to be in danger of becoming polluted as long as the Ranney collectors remain operational.

Ground-water flow directions inferred from potentiometric water levels measured in the observation wells (see Plates 1 and 2) demonstrate that, although ground-water flows generally toward the Ohio River, ground water is not discharging to the river within the boundaries of the plant property. According to pumping tests performed by the Ranney Company (1952), a good hydraulic connection between the river and the aquifer exists. This means that under natural conditions ground-water discharge to the river would be expected during most of the year, but the Ranney collectors appear to have reversed the natural hydraulic gradients in a narrow band along the river's edge. The Ranney collectors are inducing river water into the aquifer along the shore, and are capturing almost all of the ground-water flow in the aquifer (see Plates 1 and 2 and Figures 3 and 4). The arrows shown along the river bank on Plates 1 and 2 represent the flow of induced river water into the aquifer.

River Samples R1 and R2 were collected to determine whether contaminated ground water has discharged to the Ohio River. A low concentration of organic compounds (mostly aniline) was found in R2 which was obtained opposite the chemical trash dump (see Table 3 and Plates 3, 4 and 5) which would seem to indicate that contaminants in ground water are entering the river. This is probably not the case, however, because of ground-water flow patterns and because organics are discharged from the plant through river outfalls. Sample R2 was taken immediately downstream from Outfall 4.

Contaminated ground water beneath the waste disposal area in the North

Plant moves toward Ranney Collector E in a radial pattern (see Plates 1 and 2)

due to the influence of pumpage from the collector. While the present flow

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rate of 1,600 and 1,700 gpm is maintained, and even if it is significantly reduced, contaminants which enter the ground water in leachate from the waste ponds, TDI residue pile and the chemical trash dump area will eventually arrive at Ranney Collector E.

Plates 1 and 2 also demonstrate that the organic compounds which enter the ground water in the old aniline manufacturing and storage area in the North Plant will eventually be retrieved by Ranney Collectors B, C, and D as long as they are pumped to keep the water table depressed between the North and South plants.

There had been some concern among Allied personnel that a significant rise in the level of the Ohio River during the spring might cause the water table to rise above the bottom of the waste ponds in the North and South Plants and might result in a major change in ground-water flow patterns. Plates 1 and 2 show that, although water levels in the waste pond area of the South Plant are about four feet above the levels measured in June 1977, ground-water flow directions have remained virtually the same (see Ground-Water Contamination at Allied Chemical Corporation, South Plant Site, Moundsville, West Virginia, by Geraghty & Miller, Inc., September 19, 1977). Ranney Collectors A and B continue to prevent contaminated ground water beneath the waste disposal area of the South Plant, including the CMP-sulfuric acid dump, from migrating off site (see Plates 1 and 2). Tables 9 and 10 show that groundwater levels remain well below the waste pond bottoms in the South Plant and that ground water has not entered the waste in the ponds of the North Plant.



Table 9 - Elevations of South Plant Waste Pond Bottoms in Relation to Ground-Water Levels.

Pond No.	Elevation of bottom of pond (feet above mean sea level)	Elevation of ground-water level 1) (feet above mean sea level)
1	647	622-623
2	656	623
3	658	623-624
4	673	624-630 (estimate)
5 (new pond)	674	624-635 (estimate)

¹⁾ as measured on April 5, 1978

These elevations have been referred to the U.S. Geological Survey datum which is approximately two feet higher than the datum used in Plant's construction plans.

Table 10 - Elevations of North Plant Waste Pond Bottoms in Relation to Ground-Water Levels.

Pond No. (Description)	Elevation of bottom of pond ²⁾ (feet above mean sea level)	Elevation of ground-water level 1) (feet above mean sea level)
1 (NAD)	629	620-621
2	629	621-622
, 3	634	620-621
5	unknown	622-623
6	approx. 634	617-618
7 (Equalization)	633-635	622-623
8 (Settling)	633-635	622-623

¹⁾ as measured on April 5, 1978

These elevations have been referred to the U.S. Geological Survey datum which is approximately two feet higher than the datum used in the Plant's construction plans.

REMEDIAL ACTION

General Considerations

The ground-water contamination probelm at the Moundsville Plant is an extremely complicated problem because pollution abatement must be balanced with the need for a water supply that is relatively free of contamination. What follows is a list of possibilities for remedial action with a brief discussion of the advantages and disadvantages of each option. The following section contains a more detailed explanation of the option recommended by Geraghty & Miller, Inc., with specific recommendations for accomplishing specific objectives. This section is intended as an overview of all the possibilities.

The three alternatives represent a range from the most drastic action to virtually no action at all. When the decision is made to alleviate the contamination problem, specific elements from any of the three options could be combined to produce a strategem that is a variation on one of the original options. The course of action which is eventually chosen will probably, however, depend largely on the cost, necessity, and technical feasibility.

Alternative 1

This option involves discontinuing the use of the Ranney collectors and developing an alternate plant water supply, probably from the Ohio River. No action would be taken to prevent continued ground water contamination from existing unlined ponds and

dumps. Ground water levels would be allowed to rise and pollutants would be permitted to discharge to the Ohio River naturally.

<u>Advantages</u>

Of the three alternatives discussed, this is probably the least expensive. Capital construction costs of a replacement system may be high initially, but the costs of maintenance and water treatment will probably be low compared to constructing and maintaining the necessary treatment facilities for the continued use of contaminated ground water.

Disadvantages

The main disadvantage of this approach is that its legal—
ity is questionable and before it could be considered a viable alternative it would probably have to withstand an evaluation by the
appropriate regulatory agencies. It may also require the procure—
ment of additional discharge permits. Regulations governing waste
disposal facilities have become increasingly restrictive in recent
years and Allied will likely be forced into remedial action design—
ed to restrict the contamination to the plant site in the near future when RCRA becomes effective. It would be wise to plan for containment while other pollution abatement plans are being considered.

Allowing water levels in the aquifer to recover after shutting off the Ranney collectors will likely change the ground-water flow directions. While most of the contaminated ground water will probably discharge to the Ohio River, there is a possibility that

some pollutants, especially those in the South Plant, will migrate offsite under the pumping influence of the well at the Moundsville Country Club and the wells belonging to the Washington Lands public supply system. If contaminated ground water does not migrate off the plant property, Allied could also be vulnerable to legal action from property owners whose wells become unusable.

It is quite possible that ground water levels could rise into stored wastes especially in the North Plant where they were measured to be less than 15 feet below the bottoms of most ponds on April 5, 1978 (see Table 10), although it is less likely in the South Plant (see Table 9), where ground water levels are at least 25 feet below the bottoms of most ponds. Permitting ground water to enter the wastes in ponds or dumps would certainly be unacceptable to the regulatory agencies even if no attempts to contain the flow of contaminated ground water were made.

Alternative 2

This option would be designed to restrict ground-water contaminants to the plant site by pumping the Ranney collectors at a minimum flow rate but sufficiently to keep the water table below the level in the Ohio River and below the bottoms of the waste ponds at all times. The required flow rates of the Ranney wells and the pumping pattern would be determined by a ground-water mon-itoring program, although the total volume of ground water produced would be considerably less than that presently pumped. The reduced flow rates would likely make treatment of contaminated ground water

economically feasible. An alternate supply of good quality water (from the Ohio River or by recycling plant cooling water), could then be developed to make up the shortfall caused by reducing the flow rates of the Ranney collectors.

In order to minimize the quantity of contaminants entering ground water, the unlined ponds would be replaced with suitable secure facilities. The ponds would then be dewatered, and covered with a low permeability material. The chemical trash dump and the old aniline storage area in the North Plant and the CMP-sulfuric acid dump at the South Plant would also be covered with a low permeability material. The waste disposal areas in both plants would be protected from flooding to prevent river water from leaching contaminants out of the wastes. Table 11 shows that waste disposal in the North Plant will probably be flooded occasionally because the approximate land surface elevation in this area varies from about 635 to about 645 feet above MSL (mean sea level). No specific action to remove contaminants already in the ground water would be taken except to permit the Ranney collectors to slowly recover them.

<u>Advantages</u>

The major advantage to this option is that it would effect an immediate reduction of contaminants entering the ground water and prevent them from escaping the plant site. Danger of the Ohio River and neighboring wells becoming polluted would be minimized. Containment of the ground-water contaminants in conjunction with the

Table 11 - Flood Return Frequencies for the Ohio River.

Return Frequency	Expected Flood Elevations 2) (Feet Above MSL)		
(years)	MILE 105	MILE 106	
1 .	631.1	630.5	
2	633.7	633.2	
5	637.7	636.9	
10	640.5	639.9	
20	643.2	642.5	
50	646.6	646.1	
100	649.0	648.5	

- Abstracted from a letter dated October 8, 1970 to Mr. M.R. Bluntschli, Allied Chemical Corporation, from Mr. Edwin W. Thomas, U.S. Army Corps of Engineers.
- 2) Even though the Moundsville Plant is located at MILE III flood elevations are expected to be approximately the same as those listed for MILE 106.

remedial action to limit future ground water pollution would assure

Allied that the problem was under control and will probably be acceptable to regulatory agencies as a solution without requiring additional major corrective action.

The abandonment of the active hazardous waste disposal facilities would mean that they could not be construed as such when the regulations promulgated under the Resources Conservation and Recovery Act take effect. These facilities would then be subject only the less stringent "closure" rules which require monitoring for a specified length of time, limiting leaching by precipitation (accomplished in this case with a low permeability cover), and preventing ground water from entering the waste (continued pumping at the Ranney collectors will accomplish this).

Disadvantages

The cost of this alternative is likely to be quite high due to the cost of constructing and maintaining water treatment facilities, the construction of new waste disposal facilities, closure of the abandoned ponds and dumps, and the development of an alternate water supply for the plant.

Alternative 2 will require a carefully managed ground-water monitoring program that would have to be maintained indefinitely. It would be vital to obtain water level data at regular intervals to assure that the ground water levels remain below levels in the Ohio River. Water quality should also be monitored although this is not quite as important as the water level monitoring.

The Resource Conservation and Recovery Act will require monitoring in any event which means that the program establishment by Allied. will accomplish two purposes.

The quality of ground water is not likely to show signifivant improvement for many years (perhaps decades) under this option because the Ranney collectors would be depended upon to capture
contaminants already in the ground. Even though contamination will
be limited by covering the ponds and dumps, the recovery of ground
water already contaminated will be extremely slow.

Alternative 3

This alternative includes all the remedial steps listed under Alternative 2, but goes much further in attempting to remove contaminants already in the ground water. The wastes in abandoned ponds and dumps would be excavated or otherwise treated to render them innocuous, such as by encapsulation, in order to remove the sources of contamination. Wastes the facilities now hold would be disposed of in suitable facilities onsite or offsite. Scavenger wells would be installed at strategic locations to recapture contaminated ground water.

Advantages

There is no doubt that this alternative would effect the most rapid improvement of the ground-water contamination problem because it would remove sources of contamination as well as removing ground water already contaminated. Using the steps described

here, an improvement is possible within a decade. In addition, once the sources have been removed, flood protection (except for new facilities) would no longer be necessary.

Disadvantages

There are several disadvantages in addition to those listed for Alternative 2. Significant problems associated with the excavation and disposal of hazardous wastes now located on site would have to be overcome. First any attempts at removal of wastes for ultimate disposal elsewhere will be extremely expensive and may prove prohibitive. Secondly, disturbance of the wastes may result in a large release of contaminants that would otherwise remain absorbed and adsorbed to the earth materials. It would be extremely difficult, for example, to prevent contaminated runoff from the excavation pits from entering the river. Thirdly, the volume of sediments involved would be large (about 150,000 cubic yards from the chemical trash dump area alone), and it is impossible to imagine how excavation, transportation and re-emplacement could be performed in a hazard-free manner, assuming transportation could be arranged and a suitable site for disposal could be found. Fourthly, a separate treatment for the effluent from the scavenger wells may be required if the treatment system constructed to treat Ranney well water is incapable of processing this highly contaminated water.

RECOMMENDATIONS

General Comments

After considering the advantages and disadvantages of all the possible alternatives described in the previous section, it is recommended that the procedures in Alternative 2 be followed, although the use of scavenger wells discussed in Alternative 3 should be investigated. Alternative 1 is inexpensive but will probably be unacceptable to regulatory agencies, while Alternative 3 would incur a huge cost and would face immense technical and environmental problems.

What follows is, essentially, a more detailed explanation of the remedial steps outlined in Alternative 2 and the objectives each step has been designed to accomplish. The first section comments on the Resource Conservation and Recovery Act, and the second contains recommendations for action to comply to this law. The third section discusses measures to improve the chemical quality of the plant's ground water supply.

Compliance with RCRA

The Resource Conservation and Recovery Act of 1976 was signed by President Ford just before he left office. The philosophy underlying the act is that of resource reuse and conservation with a minimum of disposal. Regulations governing waste disposal facilities that will be promulgated in conjunction with this law by the USEPA (U.S. Environmental Protection Agency) are now being written. These regulations are the first in the area of waste management that require monitoring of ground water. Presently in draft form,

the regulations are constantly being revised. After each specialty group within USEPA produces a final version, the regulations will be reviewed by an administrative steering committee. They will then be published in the Federal Register for comment by the public, and hearings will be held before promulgation of the final version.

In our discussions with EPA personnel, it has become apparent that economics will be used as a means of accomplishing conservation and reuse. There is a definite tendency on the part of USEPA to make disposal so expensive that alternatives to disposal will be encouraged and sought.

Regulations and Recommendations

Specific sections of the most recent draft of RCRA regulations applicable to ground water have been abstracted and are repeated here. For each regulation a specific recommendation for remedial or corrective action tailored to comply with each regulation follows. These recommendations expand upon the discussion of remedial action in Alternative 2 which was designed to comply with RCRA draft regulations.

It must be remembered that the regulations quoted below are by no means final, but represent the most recent thinking and philosophies of USEPA. The regulations may be substantially changed between the present and the time they are formally promulgated. They may be more or less stringent then presented here.

Regulation:

"250.52 (1) All facilities shall be closed in such a manner that the land is amenable to some productive use by time of closure.

(d, 1) A final cover shall be placed over the landfill in order to minimize or eliminate infiltration of water, prevent uncontrolled sublimation or evaporation of harmful pollutants into the air, prevent erosion of wastes, support vegetation, and provide an aesthetically acceptable finished site."

Recommendation:

manner that renders them unusable and minimizes further leakage or infiltration by precipitation. This means that a cover of low permeability such as clay or compacted soil should be applied. A soil cover should be placed over this layer and graded to deflect rainfall and to support plant growth for slope stabilization.

Regulation:

"250.52, c, 2. All wastes shall be removed from ponds and lagoons which have artificial liners or others which do not meet the criteria for landfills as specified in 250.55-2. Those ponds and lagoons which meet the criteria for landfill liners shall either remove all wastes or treat the liquid wastes to render them non-pumpable and close according to the requirements for landfills as specified in 250.52-(d)." (Syntax is USEPA's.)

"250.52, a, 7. Upon final closure, all facilities shall be secured such that wastes cannot be contacted by human or animal life and such that discharges of waste harmful to human health or the

environment do not occur.

- 8. Upon final closure, equipment shall be provided and arrangements made for future ground and surface water mon-itoring at landfarms, landfills, and other sites where wastes have been disposed of and not removed.
- 9. Upon final closure, the facility owner/operator shall submit certification to the Administrator by a registered professional engineer that the facility has been closed in accordance with the requirements of the facility permit.
- 10. Upon final closure, the facility owner/operator shall file a plat with the county land authority and the Regional Administrator indicating what waste has been buried or farmed on the site."

Recommendation:

in a manner similar to landfills. As is evident from the regulations, inactive liquid or waste sludge facilities will be a definite economic liability if they exist at the time regulations are promulgated. The concept on the part of USEPA is that ultimate disposal can take place only in landfills. If an existing (active or inactive) lagoon does not conform to the construction criteria for a landfill, it must be dismantled and all wastes rendered nonpumpable and landfilled. The landfilling at that point will be required to be in a "secure" hazardous waste facility, either on or off site. If the existing lagoons are

converted to closed, covered waste facilities, the regulations for lagoons would not appear to be applicable. Plans should be made to replace active, nonconforming facilities with suitable "secure" facilities as soon as possible.

Regulation:

The regulations cited below, unless noted as Procedure, are Mandatory. The Procedures are meant to provide guidance in complying with the Mandatory regulations. The Procedures are actually suggestions which do not necessarily have to be followed. As they are now written, they are sometimes contradictory to each other, and sometimes irrelevant to the Mandatory regulation to which they are supposed to apply. There is no way of predicting at this time whether the confusion in the Procedures will be cleared up, or whether some of the Procedures will be converted to Mandatory.

Under Section 250.53-1 of the regulations, two Mandatory sections state:

"All hazardous waste treatment, storage and disposal facilities shall be monitored so as to detect any discharge."

"250.53-1, b, 1. A groundwater monitoring system consisting of a (sic) four (4) monitoring wells shall be installed for the purpose of detecting discharges at all hazardous waste treatment, storage, and disposal facilities which have the potential for discharge to usable aquifers."

The two Procedures sections dealing with chemical analyses of ground water samples state:

"250.53-1, c, 3. A minimum analysis shall quantify the follow-ing characteristics:

- (A) Specific conductivity, mho/cm at 25°C
- (B) Total dissolved solids, mg/l
- (C) Chloride (if contained in wastes), mg/l
- (D) pH
- (E) Heavy metals (two specific heavy metals) mg/l
- (F) Organic contamination by gas chromatography. If substances are shown by the GC scans to have been increased in concentration by more than 50% over background level or to have been added to the groundwater (i.e., substances which appear in the down-gradient well samples but not the up-gradient well samples), they shall be identified and quantified.
- 4. A comprehensive analysis shall quantify the following characteristics:
 - (A) All those listed in ((c)-3)
 - (B) All those listed in U.S. Primary and Secondary

 Drinking Water Standards. Except pesticides, and/
 or radioactivity if there are no pesticides and/or
 radioactivity in the wastes at the site.

- (C) Phenol, mg/l
- (D) Cyanides, mg/l"

Recommendation:

Monitoring of the ground water for chemical quanity should continue to confirm that contaminants are being prevented from crossing the plant boundaries. Water samples should be taken quarterly from all of the Ranney collectors, from Observation Wells 5, 9, 11, 12 and from Observation Clusters 22, 24, 27, 29, 32, and 38. Water samples should be analyzed for pH, hardness, chloride, specific conductance, total dissolved solids, iron, manganese, aniline, nitrobenzene, dichlorobenzene, and organohalides. If the quality of water remains nearly constant or improves in these wells over the course of one year, the sampling frequency can be reduced to semi-annually.

The requirement concerning the installation of monitor wells has probably been more than satisfied with the completion of the observation well network described earlier, although regulatory agencies may require a few more wells to be installed later. The monitor well network and the implementation of the preceding recommendations should satisfy the general mandate requiring monitoring.

For instances where ground water contamination has occurred, the prevailing regulatory philosophy has been, and it appears would continue to be, that
contamination be contained within the property boundaries. Because the
ground-water contamination appears to be contained on the Moundsville plant
site, steps should be taken to maintain the present hydrologic relationships

between ground water and the Ohio River which restrict pollutants to the plant site. The following recommendations are made with this objective in mind:

- 1. It is recommended that the Ranney collectors be pumped at a rate sufficient to keep the water table below the water level in the Ohio River and below the bottoms of the waste ponds at all times. Ranney well water could then be treated for use in the plant.
- 2. In order to verify that the water table remains below the Ohio River level, we recommend a ground-water level monitoring program. Water levels should be measured at least monthly in all of the observation wells and continuously in two new 8-inch diameter wells (one each in the North and South plants) fitted with automatic water-level recorders.
- 3. Until the pumping patterns and the minimum yield for the Ranney collectors can be established by water-level data from the monitoring program and by demand for water at the plants, Ranney Collector A should be pumped continuously at 50% of capacity and Ranney Collector E should be pumped at about 825 gpm (see letter dated April 21, 1978 in Appendix B).
- 4. An automatic river level recorder should be installed at a convenient location along the river, perhaps on the barge dock. This instrument would serve to keep a continuous record of the elevation of the river level.

- 5. The laterals extending toward the river in all the Ranney collectors may be sealed provided the concentrations of contaminants do not rise so high as to overload the treatment plants. This action will serve to decrease the proportion of river water and increase that of ground water reaching the wells. The Ranney collectors will then become a more efficient barrier against the flow of contaminated ground water to the river.
- 6. A magnetic flow meter should be installed at each Ranney collector.

 Accurate flow rate measurements will be needed to design water treatment

 plants, establish a suitable pumping pattern, and will be extremely helpful

 if additional hydrogeologic studies are anticipated.
- 7. Because the waste disposal area is likely to be subjected to flooding (see Tables 1 and 11), consideration should be given to flood protection
 structures to prevent river water from leaching contaminants out of the
 waste disposal facilities.

Improvement of Ground-Water Quality

Even if RCRA regulations take effect in a less stringent form, and many of the items quoted are eventually not required by law, the remedial action recommended to comply with the regulations presently in draft form will eventually result in an improvement of ground water quality. With the possible exception of reducing the flow rates from Ranney collectors which will tend to slow the recovery of contaminated ground water (but may be counteracted by sealing the laterals extending toward the river), low permeability covers over unlined ponds and dumps and the possible use of scavenger wells can

result in less contamination. It must be remembered, however, that a significant reduction in ground water contamination probably cannot be accomplished for some years even if the sources of contaminants were completely removed. The portion of the plant water supply made up by ground water will contain contaminants for some time to come, although their concentrations should slowly decrease after remedial action has been taken. With this in mind the following recommendations are made.

- 1. The chemical trash dump and the old aniline storage area in the North Plant and the CMP-sulfuric acid dump in the South Plant should not be excavated to eliminate these sources of ground water contamination. Excavation and disposal of the wastes in these areas will be very difficult technically, will probably result in additional contamination of the environment, may be dangerous, and will be extremely expensive (probably prohibitive).
- 2. Remedial action to alleviate ground-water contamination from the three areas mentioned in the previous paragraph should be limited to covering them with a low permeability material.
- 3. The use of scavenger wells to capture leachate from the waste ponds should be investigated. Scavenger wells will further reduce the quantity of contaminants reaching the ground-water system, provided a practical and economical way can be found to treat the effluent from the wells.
- 4. No geophysical investigation to locate bedrock depressions that may be harboring organic contaminants should be undertaken. Such an

investigation will yield little useful information for a large expenditure.

Respectfully submitted,

GERAGHTY & MILLER, INC.

Nicholas Valkenburg Senior Hydrogeologist

Nicholas Valberbur

Olin C. Braids

Olin C. Braids
Senior Scientist
Osh Asbuta

John Isbister Vice President

Meg.

REFERENCE

The Ranney Company, 1952, Report on hydrogeological survey for the Solvay Process Division, Moundsville, West Virginia, Survey No. S-42.

Geraghty & Miller, Inc.

APPENDIX A

Selected Well Logs

GERAGHTY & MILLER

44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11030

WELL LOG

PROJECT Allied Chemical Corp.

CLIENT Moundsville, W. Virginia

DATE PREPARED 4/21/78 BY EAL after NV

Page (9)

		OWNER Allied Chemical
DEPTH, ft	DESCRIPTION	WELL NO. Obs. Well 20
· ·		LOCATION north plant
0 —		
1 1	Sand, fine to medium, tan;	TOPO SETTING
} -}	trace tan silt	GROUND ELEV.
1 1	trace tan siit	
]		DRILLING STARTED 1/31/78
] .]	Sand, fine to medium, tan; little	DRILLING COMPLETED
10+	tan silt; little medium to coarse	DRILLER
1 - 1	gravel; single pebble	TYPE OF RIS
j _j '	Silt, clayey, tan; and sand, fine	
} }	to coarse; and gravel, fine to	WELL DATA
' } ;	coarse	HOLE DIAM.
1 1 1		FINAL DEPTH
20+		CASING DIAM.
4	Gravel, fine to coarse, white,	CASING LENGTH
1	black and green; some sand, fine	SCREEN DIAM.
İ	to coarse; trace yellow silt in	SCREEN SETTING
1 1	upper section	SCREEN SLOT & TYPE
-		WELL STATUS
30+		
		DEVELOPMENT
]]	Sand, fine to coarse, tan, brown,	
]] [and gray; some fine to coarse	
1 1	black and green gravel; trace	
	silt in upper section; odor of	
40↓	organics in lower section	
} }	•	TEST DATA
		STATIC DEPTH TO WATER
7 1		DATE MEASURED
		PUMPING DEPTH TO WATER
1		DURATION OF TEST
50∔	no sample	PUMPING RATE
	Cond fine to come to the	DATE OF TEST
} }	Sand, fine to coarse, tan; trace	TYPE OF TEST
7	to little silt in upper section;	PUMP SETTING
-	little fine to medium black and	SPECIFIC CAPACITY
-	green gravel in lower section	
60+		FINAL PUMP CAPACITY
	Gravel, fine to coarse, black,	FINAL PUMP SETTING
1 1	green and gray; some to little,	AVERAGE PUMPAGE
7]	tan to gray clayey silt; some fine	
1	to coarse sand; several pebbles	WATER QUALITY
	and organic odor in lower section	
70+		
,]	Sand, fine to coarse, gray; some	
	fine to medium gravel; trace gray	
7 1	silt; organic odor	
4 1		
4 1		REMARKS
80 <u> </u>	Bedrock	
	•	

GERAGHTY & MILLER 44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical Corp.

CLIENT Moundsville, W. Virginia

DATE PREPARED 4/21/78 BY EAL after NV

	,	OWNERAllied Chemical
DEPTH, ft	DESCRIPTION	WELL NO. Obs. Well 21
1		LOCATION
0		
	Sand, fine to coarse, gray; and	TOPO SETTING
{	fine to coarse gravel; little silt	GROUND ELEV.
1 4 1	or clay; several large pebbles;	
]] ;	nitrobenzene odor	DRILLING STARTED 2/2/78
}	Clayey silt, organic brown; some	DRILLING COMPLETED
10 +	coarse to fine sand; several	DRILLER
]	pebbles; nitrobenzene odor	TYPE OF RIG
1 4 1		
]]]	Gravel, fine to coarse, yellow,	WELL DATA
	tan, brown, gray and black; little	HOLE DIAM.
	coarse to fine sand; little to	FINAL DEPTH
' 20 +	trace silt; nitrobenzene and/or	CASING DIAM.
- 11	D C B odor	CASING LENGTH
1 - 1		SCREEN DIAM.
, , , ,	ļ	SCREEN SETTING
		SCREEN SLOT & TYPE
30 +		WELL STATUS
7º T		
1 1 F	Cond normal to fine annual to the	DEVELOPMENT
	Sand, coarse to fine, gray; some	
	coarse to fine gravel; trace silt;	
i 4 h	nitrobenzene odor	
40 1	Clayey silt, gray to tan; little	
70 7	to trace coarse to fine sand; 2	
' 1 1	pebbles; nitrobenzene odor	TEST DATA
		STATIC DEPTH TO WATER
	į	DATE MEASURED
4 1	Gravel, coarse to fine, tan;	DURATION OF TEST
- 50 ↓	little coarse to fine sand; some	PUMPING RATE
	tan clay or silt; nitrobenzene odor	
7 F	Pebbles, white & red; little	TYPE OF TEST
1	coarse to fine sand; little tan	PUMP SETTING
	silt; nitrobenzene odor	SPECIFIC CAPACITY
60 +	Sand, coarse to fine, yellowish	FINAL PUMP CAPACITY
1 1	tan; little coarse to fine gravel;	FINAL PUMP SETTING
	trace silt; nitrobenzene odor	AVERAGE PUMPAGE
	2. 200 27. C, C. 200. 20. 20. 20. 20. 20. 20. 20. 20. 2	
7	ļ	WATER QUALITY
L		
70 +		
- -	Bedrock	
1 1		
_	1	
	· •	DEMARKS
80]	İ	REMARKS
ψυ - - ']	

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GERAGHTY & MILLER

44 SINTSINK DRIVE EAST
PORT WASHINGTON, L.I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical, Moundsville
CLIENT Allied Chemical Corp.

DATE PREPARED 5-12-78 SYEAL after CR

		
		OWNER Allied Chemical Corp.
		WELL NO24
DEPTH, ft	DESCRIPTION	
0 —	 -	LOCATION Moundsville, West Virginia
	Sand, silty; some clay; slight odor.	
1	Sand, Strey; Some Clay; Stright Odor.	TOPO SETTING
4		GROUND ELEV.
1		
1		DRILLING STARTED
1		DRILLING COMPLETED
10 🕂	Clay, silty, light brown; rounded	
	quartz pebbles in lower section;	DRILLER
1	slight DNB odor.	TYPE OF RIG
	STIGHT DAD OGOT.	
		WELL DATA
1		HOLE DIAM.
1		FINAL DEPTH
20 +		CASING DIAM.
ŀ		
7	Silt, light brown; with fine light	CASING LENGTH
	brown sand; slight odor.	SCREEN DIAM.
1	DIOMI Sand, STIGHT OUDI.	SCREEN SETTING
		SCREEN SLOT & TYPE
†		WELL STATUS
30 +	Clay, cohesive; one large quartz	
	pebble; slight DNB odor.	BENELOBARAN
7	The state of the s	DEVELOPMENT
	Sand, silty, light brown; small	
4	vitreous slag fragments; moderate	
	_DNB odor.	
7 1		
40 🕂	Clay, silty; strong DNB odor.	
		TEST DATA
7 1		· · · · · · · · · · · · · · · · · · ·
1 1		STATIC DEPTH TO WATER
		DATE MEASURED
		PUMPING DEPTH TO WATER
ر م	O	DURATION OF TEST
50 🕂	Gravel, coarse to fine, black, white	PUMPING RATE
4 1	<pre>& tan; little coarse to fine sand;</pre>	DATE OF TEST
	little silt; few pebbles in lower	TYPE OF TEST
7 1	section; DCB or nitrobenzene odor.	PUMP SETTING
4 !	•	
4 1		SPECIFIC CAPACITY
60 ⊥		
		FINAL PUMP CAPACITY
		FINAL PUMP SETTING
4 1		AVERAGE PUMPAGE
إ إ		
7 /		WATER QUALITY
70 👃		
•		
1 1		
4 1	Silt, clayey, gray; little gravel	
]]	in lower section; strong DCB ador.	
7 1		
-		REMARKS
8o ⊥ ∣		

GERAGHTY & MILLER 44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical, Moundsville
CLIENT Allied Chemical Corp.

DATE PREPARED 5-12-78 BY EAL after CR

		DATE PREPAREDS 12 10 BY MILE OF CO.
		OWNER Allied Chemical Corp.
DEPTH, ft	DESCRIPTION	
80	_	LOCATION Moundsville, West Virginia
	Silt (continued)	
1 1	3116 (continued)	TOPO SETTING
-		GROUND ELEV.
4		
		DRILLING STARTED
		DRILLING COMPLETED
90 🕂		DRILLER
-	Gravel, coarse to fine, gray & tan;	TYPE OF RIG
	little fine to coarse sand; little	
_	gray silt.	WELL DATA
]	gray street	HOLE DIAM.
1 1		FINAL DEPTH
100 +	Bedrock	CASING DIAM.
4		CASING LENSTH
		SCREEN DIAM.
7		SCREEN SETTING
		SCREEN SLOT & TYPE
4 1		WELL STATUS
_ ↓		MELL SINIOS
]		DEVEL ABOVE UP
7 1		DEVELOPMENT
7 1		
-		
- 1		
1		
T I		
1 1		TEST DATA
		STATIC DEPTH TO WATER
4 (DATE MEASURED
_		PUMPING DEPTH TO WATER
i i		DURATION OF TEST
† [PUMPING RATE
4 1		DATE OF TEST
		TYPE OF TEST
1		PUMP SETTING
[[SPECIFIC CAPACITY
7		
+		FINAL PUMP CAPACITY
4 1		FINAL PUMP SETTING
4 (AVERAGE PUMPAGE
] [
3 [WATER QUALITY
1		
+ [
4 1		
١ ز		
7 }		
1		
+ 1		REMARKS
1 1		

GERAGHTY & MILLER

44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical, Moundsville CLIENT Allied Chemical Corp.

DATE PREPARED 5-15-78 BY EAL after NV

 $R_{G,i}$

		OWNER Allied Chemical Corp.
DEPTH, ft	DESCRIPTION	WELL NO. 26
0	-	LOCATION Moundsville, West Virginia
	Top soil, black; strong nitrobenzene	
	odor.	TOPO SETTING
1	1 3301.	GROUND ELEV.
†	}	DRILLING STARTED
4	}	DRILLING COMPLETED
10 +		ORILLER
1		TYPE OF RIS
		WELL DATA
1	<u></u>	HOLE DIAM.
1	Silt, black; strong odor of organics.	FINAL DEPTH
20 🕂		CASING DIAM.
4		CASING LENGTH
		SCREEN DIAM.
.]	Silt, clayey, gray; strong odor of	SCREEN SETTING
7	organics.	SCREEN SLOT & TYPE
1		WELL STATUS
30 +	}	
4		DEVELOPMENT
4	Gravel, coarse to fine, black; little	
	coarse to fine sand; little pebbles;	
	strong DCB or nitrobenzene odor.	
40]	Silt, clayey, gray to black; little	
*º †	coarse to fine sand; strong DCB or	
4	nitrobenzene odor.	TEST DATA
4		STATIC DEPTH TO WATER
<i>,</i>	Sand, coarse to fine, gray; strong	PUMPING DEPTH TO WATER
	DCB or nitrobenzene odor.	DURATION OF TEST
50 🕂		PUMPING RATE
30		DATE OF TEST
7		TYPE OF TEST
7		PUMP SETTING
4		SPECIFIC CAPACITY
4		
60 🕂		FINAL PUMP CAPACITY
1 .	Gravel, coarse to fine, gray; little	FINAL PUMP SETTING
]	coarse to fine sand; little gray silt;	AVERAGE PUMPAGE
1	strong DCB or nitrobenzene odor.	
1		WATER QUALITY
1		
70 +	Silt, clayey, gray; and coarse to fine	
4 :	gravel; little coarse to fine sand;	
1	some pebbles; strong D C B or	
	nitrobenzene odor.	
. 7		
_ 1		REMARKS
80 +		
1		
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GERAGHTY & MILLER

44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical, Moundsville
CLIENT Allied Chemical Corp.

DATE PREPARED 5-11-78 BY EAL after CR

		OWNER Allied Chemical Corp.
DEPTH, ft	DESCRIPTION	WELL NO. 27
· ·	DESCRIPTION	LOCATION Moundsville, West Virginia
° 7	Silt, sandy, light brown to grayish	
	black; and organic clay; some angular	TOPO SETTING
-{ !	quartz & green rock fragments; slight	GROUND ELEV.
]	DNB odor.	
_	5.15 GGG7 .	DRILLING STARTED
4.		DRILLING COMPLETED
10 +		DRILLER
1 1		TYPE OF RIS
-		
4 1		WELL DATA
	Clay, silty, brown; some DNB odor.	HOLE DIAM.
20 📗	ctay, strey, brown, some bab odor,	FINAL DEPTH
20 T		CASING DIAM.
1 F	Sand, silty; and rounded quartz peb-	CASING LENGTH
	bles; some TDI residue (black chips).	SCREEN DIAM.
4	bles, some for residue (black chips).	SCREEN SETTING
_	Clay, silty, light brown to brown;	SCREEN SLOT & TYPE
30 +	with pebbles & rock fragments.	WELL STATUS
>º T	with pennies & rock fragments.	
1 }		DEVELOPMENT
- - 1	Sand, yellowish to greenish to grayish	
4	brown; and yellowish to grayish brown	
4 }	gravel; some weathered green pebbles	
40 1	8 large rounded or angular rock frag-	
- T 1	ments; some silt; some foreign mater-	
7 1	ial; slight to moderate DNB odor in	TEST DATA
i i	lower section.	STATIC DEPTH TO WATER
- 1		DATE MEASURED
		DURATION OF TEST
50 ↓ │		PUMPING RATE
] [DATE OF TEST
7 F	Clay, brown; with rounded pebbies;	TYPE OF TEST
7 1	some TDI residue; slight odor.	PUMP SETTING
4		SPECIFIC CAPACITY
4 5		
60 📗	Sand, clayey, brown; and gravel; some	FINAL PUMP CAPACITY
1	brown silt and rounded quartz pebbles.	FINAL PUMP SETTING
		AVERAGE PUMPAGE
]]	ļ	
7 1		WATER QUALITY
1 1	Sand, clayey, grayish brown; and fine	
70 🕂 📗	to coarse gravel; with rounded peb-	
1 1	bles; very slight DNB odor.	
] [<u> </u>	
}	Podmost.	
1	Bedrock	
4		REMARKS
80 丄 1	•	
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44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical, Moundsville
CLIENT Allied Chemical Corp.
DATE PREPARED 5-11-78 BY EAL after CR

DEPTH, ft	DESCRIPTION	OWNER Allied Chemical Corp. WELL NO. 28 LOCATION MOUNDSVIILE, West Virginia
0	To the state amonto come clay	LOCATION HOUNGSVIITE, WEST VIIGINIA
4	Sand, fine, silty, organic, some clay.	TOPO SETTING
_	}	GROUND ELEV.
-		
4	Sand, fine to coarse, silty organic;	DRILLING STARTED
10 丄	some clay & pebbles; slight DNB odor.	DRILLING COMPLETED
_	i	TYPE OF RIG
	Sand, coarse, brownish orange; some	
	rounded brownish green pebbles; some	WELL DATA
]	clay.	HOLE DIAM.
]	s at and amount poorly corted:	FINAL DEPTH
20 +	Sand; and gravel; poorly sorted; slight nitrobenzene odor.	CASING DIAM.
7	Sildir intropenzene odor.	CASING LENGTH
† i		SCREEN DIAM.
4		SCREEN SLOT & TYPE
4 1	Sand, silty; with gravel & angular	WELL STATUS
30 +	rock fragments; some black pebbles &	
4	clay blebs.	DEVELOPMENT
4]	Silt, light brown; and sand; some	
4 1	quartz pebbles; few rock fragments;	
4 1	some DNB odor. Silt, fine, light brown; little vitre-	
40 +	ous slag; some pebbles; one angular	
, ,	striated rock fragment.	TEST DATA
	Gravel, 30% quartz; some silty sand;	STATIC DEPTH TO WATER
<u> </u>	angular rock fragments & large orange	DATE MEASURED
]	& dark green pebbles; slight DNB odor.	PUMPING DEPTH TO WATER
50]	Gravel, fine, sandy; with silt; some	DURATION OF TEST
7 †	rounded quartz & black pebbles; some	PUMPING RATE
1 1	feldspar & granitoid rock fragments; \small vitreous slag fragments; mode-	TYPE OF TEST
7 1	rate DNB odor.	PUMP SETTING
-	Silt, sandy; with large pebbles, ang-	SPECIFIC CAPACITY
	\ular rock fragments & vitreous slag;	
60 +	\moderate odor.	FINAL PUMP CAPACITY
	Clay, light brown to brownish green;	FINAL PUMP SETTING
-	some rounded brown & green pebbles;	AVERAGE PUMPAGE
-	\slight odor.	WATER QUALITY
-	Gravel, coarse to fine, gray & tan; some coarse to fine sand; little silt;	
70 \downarrow	DCB or nitrobenzene odor.	
_	565 Of 1116.050.120.10 Coo. 7	
_		
] {		
]		REMARKS
80]		TENTANDIN
30 (Bedrock	

GERAGHTY & MILLER 44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical, Moundsville CLIENT Allied Chemical Corp.

DATE PREPARED 5/12/78 BY EAL after CR

		OWNER Allied Chemical Corp.
DEPTH, ft	DESCRIPTION	WELL NO. 29
		LOCATION Moundsville, West Virginia
° —		
7	Soil, silty, organic, brown; some	TOPO SETTING
	roots; slight odor.	GROUND ELEV.
4		
1	 , 	DRILLING STARTED
.]	Soil, silty, organic, brown; with	DRILLING COMPLETED
10 +	brown clay; moderate DNB odor.	DRILLER
4		TYPE OF RIG
4	Silt, clayey, cohesive, light brown	
_}	to brown; some sand; trace slag;	WELL DATA
ļ	slight odor.	HOLE DIAM.
1		FINAL DEPTH
20 🕂	1	CASING DIAM.
4		CASING LENGTH
]	Clay, silty, cohesive, brownish green;	SCREEN DIAM.
1	some quartz pebbles; some black dis-	SCREEN SETTING
7	coloration from slag; moderate to	SCREEN SLOT & TYPE
4	strong nitrobenzene odor.	WELL STATUS
30 +	Silt, clayey, grayish to greenish	
4	brown; with sand; some orange & black	DEVELOPMENT
	fragments of foreign material; strong	,
7	nitrobenzene odor in upper section;	
4	slight DNB odor in lower section.	
- 1	Stigit but odor in lower section.	
40 🗼	Sand, coarse, silty, grayish green;	
	some grayish green gravel, rounded	TEST DATA
7	quartz & black pebbles, & angular	STATIC DEPTH TO WATER
7	rock fragments; slight to moderate	DATE MEASURED
4	DNB odor.	PUMPING DEPTH TO WATER
-}		DURATION OF TEST
50 ∔	Clay, silty, cohesive, light brown;	PUMPING RATE
- }	some small black pebbles & angular	DATE OF TEST
7	vitreous black slag fragments; mod-	TYPE OF TEST
7	erate nitrobenzene odor.	
4		PUMP SETTING
7	 	SPECIFIC CAPACITY
60 🕹	Clay, silty, grayish brown.	FINAL PUMP CAPACITY
		FINAL PUMP SETTING
7		
4		AVERAGE PUMPAGE
4	Bedrock	WATER QUALITY
4		WALER WUNLIT
70 🗼	ł	
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1	(REMARKS
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	1	
	· ·	

GERAGHTY & MILLER 44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical Corp.

CLIENT Moundsville, W. Virginia

DATE PREPARED 4/21/78 BY EAL after CR

05PTH, ft	DESCRIPTION	OWNER Allied Chemical WELL NO. Obs. Well 32 LOCATION
-	Clay, fine, silty, organic, brown; some sand; slight odor	TOPO SETTING
10 +	Clay, organic, brown & black; some sand & gravel; some oxidized material	DRILLING STARTED 2/17/78 DRILLING COMPLETED DRILLER TYPE OF RIG
20 +	Sand, coarse, gray; and coarse gray gravel; with rock fragments	WELL DATA HOLE DIAM. FINAL DEPTH CASING DIAM. CASING LENGTH
-	Gravel, very coarse, yellowish brown; and rounded pebbles and rock fragments	SCREEN DIAM. SCREEN SETTING SCREEN SLOT & TYPE WELL STATUS
30 +	Sand, clayey, blue-gray; and blue-gray gravel; some black silt	DEVELOPMENT
40	Sand, gray, blue & brown; some small pebbles	TEST DATA
	Sand, silty, gray; with fine to medium gravel; some rounded black pebbles	STATIC DEPTH TO WATER
50 +	Silt, clayey, brown; with small rounded pebbles; slight odor	DURATION OF TEST PUMPING RATE DATE OF TEST TYPE OF TEST
60	Pebbles, rounded; and brownish gray clay; some rock fragments	PUMP SETTING
70	Gravel, coarse; and coarse sand; with greenish gray clay; some white rock fragments & pebbles; slight DNB odor	WATER QUALITY
80	Sand, grayish brown; and gravel; with rounded pebbles and black and orange rock fragments; slight DNB odor	REMARKS

GERAGHTY & MILLER

44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

CIGINAL	
(Red)	

WELL LOG

PROJECT		 		 	
CLIENT		 		 	
DATE PREPA	ARED	 	. 61	 	

		DATE PREPARED
		OWNER
		WELL NO. Obs. Well 32
DEPTH, ft	DESCRIPTION	
•	_	LOCATION
89 7 7	(continued)	
		TOPO SETTING
- 1	Gravel, coarse, gray, green, & brown; with coarse sand; some small	GROUND ELEV.
1 1	rounded pebbles; some DNB odor	DRILLING STARTED
4 F	Gravel; with silty, greenish brown sand; some light bluish green silt	
90 ↓ ↓	<u> sa</u> nd;some light bluish green silt	DRILLING COMPLETED
T	Bedrock	DRILLER
1	pedrock	TYPE OF RIG
4 1		
1 1		WELL DATA
1 1		
1		HOLE DIAM.
1 1		
TI		CASING DIAM.
4 1		CASING LENGTH
1 1		SCREEN DIAM.
	i	SCREEN SETTING
7 1		SCREEN SLOT & TYPE
4 1		WELL STATUS
1 1		WELL SIATUS
T 1		
+ 1		DEVELOPMENT
4 1		
7 1		
1		
1 1		
1 1		
- 1		TEST DATA
4 1		STATIC DEPTH TO WATER
_[DATE MEASURED
7 1		PUMPING DEPTH TO WATER
4		DURATION OF TEST
4 1		PUMPING RATE
		DATE OF TEST
1 1		
4 1		TYPE OF TEST
		PUMP SETTING
1 1		SPECIFIC CAPACITY
1 1		
+ [FINAL PUMP CAPACITY
		FINAL PUMP SETTING
7]		AVERAGE PUMPAGE
4 1		HATTINGE LAMENAR
4 1		MATER ALIALITY
1 1		WATER QUALITY
1		
+	· ·	
]		
7]		
4		
1	·	
7 [REMARKS
1		
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GERAGHTY & MILLER

44 SINTSINK DRIVE EAST PORT WASHINGTON, L. I., N. Y. 11050

WELL LOG

PROJECT Allied Chemical Corp.

CLIENT Moundsville, W. Virginia

DATE PREPARED 4/21/78 SYEAL after CR

		OWNER Allied Chemical
		WELL NO. Obs. Well 33
DEPTH, ft	DESCRIPTION	
0		LOCATION
9 7		
		TOPO SETTING
1 1	Silt, fine, clayey, brown	GROUND ELEV.
+ 1		2/16/79
		DRILLING STARTED 2/16/78
10 丄		DRILLING COMPLETED
'' +	Clay silty light brown	DRILLER
4 1	Clay, silty, light brown	TYPE OF RIG
1 1		
4 1	i	WELL DATA
		HOLE DIAM.
7	i	FINAL DEPTH
20 📙		CASING DIAM.
	Silt, coarse, sandy, rust brown	
7 1		CASING LENGTH
4 [SCREEN DIAM.
] [SCREEN SETTING
1 L		SCREEN SLOT & TYPE
+ _ [Clay, silty, brown; with large	WELL STATUS
30 📗	rounded pebbles; some sand	
	, ,	
1 J-	Ford blue grows and blue-grow	DEVELOPMENT
4 1	Sand, blue gray; and blue-gray	
1 1	gravel; with pebbles & rock frag-	
₹	ments; surficial discoloration	
4 1		
40	(unidentified)	
7		
- L	Clay, silty, brown; with gravel and	TEST DATA
		STATIC DEPTH TO WATER
		DATE MEASURED
4	Sand; and gravel; with rock	PUMPING DEPTH TO WATER
4 1	fragments; some silty clay; TDI	DURATION OF TEST
50⊥	residue & slight to moderate	
7	DNB odor in lower section	PUMPING RATE
L		DATE OF TEST
] [Pebbles, brownish gray; and	TYPE OF TEST
7	brownish gray silt; slight to	PUMP SETTING
	moderate odor in lower section	SPECIFIC GAPACITY
	Modelate odol III lower section	SPECIFIC CAPACITY
60]		
00+		FINAL PUMP CAPACITY
-	i	FINAL PUMP SETTING
	Clay, silty, brown; with rounded	AVERAGE PUMPAGE
7 1	pebbles; some gravel; some roots;	
4 1		WATER AUALITY
] [-	moderate odor	WATER QUALITY
7	i	
70-	Bed rock	
]		
1	Į.	
4		
]		
} \	1	
4 1		REMARKS
80±		
	ľ	

APPENDIX B

Pertinent Correspondence

Geraghty & Miller, Inc.

Water Research Building 44 Sintsink Drive East Port Washington, New York 11050 Cable: WATER

CONSULTING GROUND-WATER GEOLOGISTS AND HYDROLOGISTS

Telephone: 515/883-6760

January 27, 1978

Mr. M. Y. Yang, Project Engineer Allied Chemical Corporation Specialty Chemicals Division P.O. Box 1087R Morristown, New Jersey 07960

Subject: Geophysical Investigations at Allied's Specialty Chemicals (North) Plant in Moundsville, West Virginia

Dear Mr. Yang:

As was requested at the meeting in Morristown on January 6, 1978, we have contacted a company specializing in geophysical surveys concerning the feasibility and cost of identifying bedrock depressions in which organic contaminants may have accumulated. We understand that any such survey would be performed after the results of the hydrogeologic study outlined in our proposal to John Bresland (dated December 8, 1977) have been obtained. The monitor well network to be installed should determine whether a discrete and widespread organic phase is present in the aquifer, and should an extensive separate hydrocarbon phase be encountered, the geophysical survey might be used in conjunction with an expanded drilling program to find depressions which may be harboring the contaminants.

According to Mr. Vin Murphy of Weston Geophysical Research, Inc., his company would be able to detect bedrock depressions or channels, as long as they were larger than about 10 feet in diameter (or long) and about 5 feet deep. A surface layer of snow, frozen ground, or extraneous noise evidently are not problems so that the geophysical survey could be done during the winter. The cost of covering a 2 million square foot area (2,000 ft by 1,000 ft) in the vicinity of the contaminated Ranney well would range from \$10,000 to \$25,000 and would require 6 weeks to complete.

Because of the possibility of uncertain results and the high cost, an experimental 2,000 ft long profile should probably be attempted first before attempting to cover the entire area, as you have suggested to John Isbister. Any depression encountered could then be drilled to determine

Geraghty & Miller, Inc.

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January 27, 1978

(Rea)

Mr. M. Y. Yang Allied Chemical Corporation

whether organics are present, and should this stratagem prove successful it could be expanded to cover the entire area. A single profile would require 2 to 5 days work and would cost about \$4,350. Although Allied's name was not mentioned to Mr. Murphy, he has offered to make himself available at 617/366-9191 if you would like to contact him directly.

If you have any questions or require additional explanation, please do not hesitate to contact me or John Isbister.

Sincerely,

Micholas Vallenberro

Nicholas Valkenburg Hydrogeologist

NV:am

cc: John Isbister

Geraghty & Miller, Inc.

Water Research Building 44 Sintsink Drive East Port Washington, New York 11050 Cable: WATER

CONSULTING GROUND-WATER GEOLOGISTS AND HYDROLOGISTS

Telephone: 516/883-6760

April 21, 1978

Mr. Larry C. Taylor, Project Manager Allied Chemical Corporation Specialty Chemicals Division P.O. Box 1087 R Morristown, New Jersey 07960

Dear Mr. Taylor:

We have completed our hydrogeologic analysis of the Ranney Well E at Allied Chemical's (North) Plant in Moundsville as you requested at our meeting in Morristown on March 29. The purpose of the analysis was to determine the minimum flow rate at which the well can be pumped and still capture the contaminants entering the ground water from the various sources of contamination.

Water level measurements taken on February 23 and April 5 in the observation wells around the Ranney Well (while pumping at about 1,650 gpm) show that its pumping influence extends to a distance of approximately 2,000 feet. This is apparently more than sufficient to capture virtually all of the contaminants entering the ground water from the TDI residue pile, NAD pond, pond No. 2, the EPDM lined pond (pond No. 3) the chemical trash dump, and the lime waste pond (pond No. 1). The minimum radius of influence required to capture contaminants from all but the lime waste pond, which is probably not a serious source of pollution, is about 1,500 feet. In order to achieve this minimum radius the flow rate from the Ranney Well may be reduced to around 825 gpm (gallons per minute).

We would like to emphasize that the minimum flow rate given about represents an estimate because several assumptions about aquifer conditions were necessary in order to perform the analysis. We recommend that the flow rate be reduced to 825 gpm as a beginning, then after the Ranney has been pumping for about a week at the reduced flow rate, the water levels in the observation wells be measured again. The construction of a new water table map should confirm that the radius of influence at the new flow rate is adequate. If the radius is found to vary significantly from 1,500 feet the Ranney flow rate can then be re-adjusted as required.

We also recommend the water levels in the observation wells be measured periodically after the flow has been reduced to make sure the radius of the Ranney Well remains adequate. Seasonal changes in the river level may alter the pumping radius of the Ranney Well somewhat which means that the well may

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have to be pumped at a slightly higher rate (approximately 1,000 gpm) during the dry season in order to maintain the 1,500 foot radius. Also the plant should continue to monitor the quality of water pumped from the well because it may change significantly after the flow rate has been reduced, although the changes in quality cannot be predicted.

The field work for the current hydrogeologic investigation at the Moundsville plant is complete. Fifty-three monitor wells were constructed at 22 locations and at least one water sample was collected from each well for analysis during February, 1978. Ranney Collector E and observation Wells 26, A, B, C were resampled during the week of April 3 and samples from observation Wells 1, 15, 16, 17, 18 and PTI (drilled during a study performed by Dr. Wayne Pettyjohn of Ohio State University) were collected for the first time also during the week of April 3. Water levels were measured in each of the wells on February 23 and again April 5 in order to construct the water table maps necessary to determine contaminant flow paths. On April 5 Wells 26A and 26C were swabbed with cotton to determine if any organic phase similar to that accumulating in Ranney Collector E is present in the aquifer. No discrete organic phase could be detected in these two observation wells.

We expect to have our report completed in about 3 weeks time although we are still awaiting the analytical results for the water samples collected during the week of April 3. We can tentatively arrange for a formal presentation of our findings and recommendations to be made at the end of the week of May 15 or at the beginning of the following week, if that is convenient.

We would like to be notified if and when the flow rate of Ranney Well E is to be reduced so that we can send someone to Moundsville to measure the water levels (provided you approve) in the surrounding observation wells. In the meantime if you have any questions or require additional information, please contact us.

Sincerely,

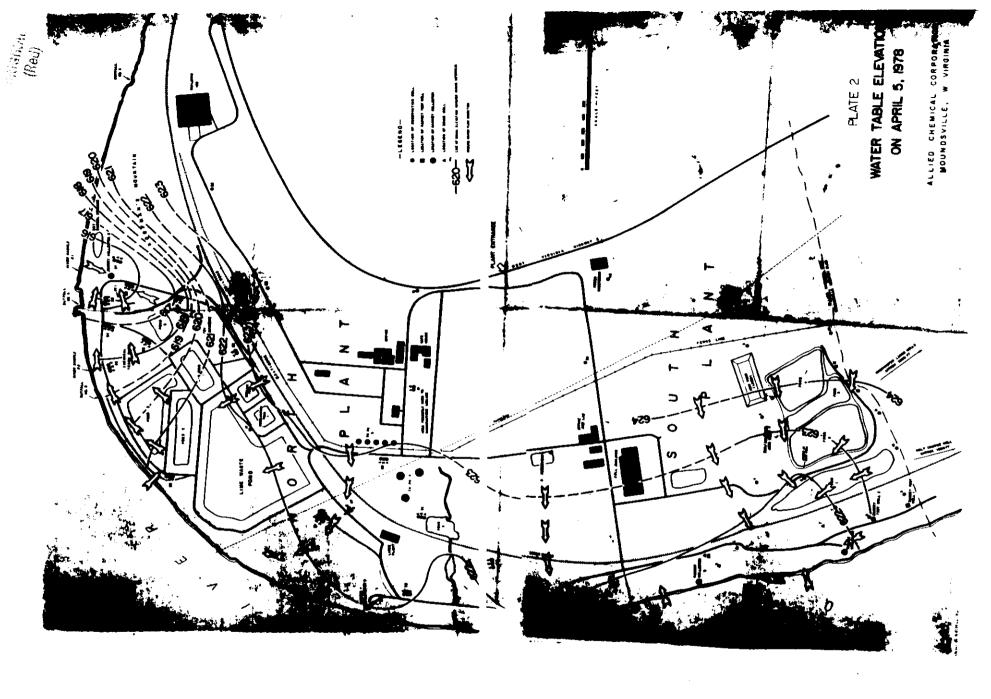
GERAGHTY & MILLER, INC.

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Hydrogeologist

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